SANITARIAN'S HANDBOOK

THEORY AND ADMINISTRATIVE PRACTICE

BY

BEN FREEDMAN, M. D., M. P. H.

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Third Edition

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Theory and Administrative Practice

By

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To my wife

and

my friends

who,

in their own devoted ways,

made this work possible.

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SANITARIAN'S HANDBOOK

THEORY AND ADMINISTRATIVE PRACTICE

PREFACE

The general Administration of environmental hygiene in the United States tends to come under the ultimate direction of the medical health officer, though technical supervision is usually in the hands of the public engineer. The field operations and direct administrative work is, for the most part, carried on by the sanitarian. He is the unsung hero of front line action. He mingles with the people, molds their sanitary habits and practices, and sows among them the seeds that will germinate into hygienic habits. He translates the sanitary theories into everyday usage, promotes adherence to health rules, and seeks out and pursues the hazards that stalk every household and town.

The sanitarian, more than any other health worker is directly involved in interpreting sanitary theory to the public and in keeping the increasingly complex environment a safe place in which to live. In order to accomplish this task adequately, he must be fortified with a wide range of information that gives him the ability to recognize and to control environmental hazards, and to know when to call upon the engineer, the physician, or other specialist for counsel. He must be confident and facile in explaining matters of sanitation to the public, and, in doing so, to reflect the dignity of his position. The knowledge which the sanitarian should possess adds up to a very liberal education. Great progress has been made in accomplishing this goal in recent years. It is the task of those responsible for training the sanitarian to create a literature which will tend to meet his basic educational needs, and at the same time to stimulate him to higher levels of learning. It is the duty of every sanitarian to carry on the research necessary to enlarge the sanitarians professional literature. Universities are initiating regular college courses leading to degrees in sanitation. The sanitarian is more and more availing himself of graduate education in public health.

When the author first undertook the training of public health personnel, he was particularly impressed with the lack of well organized and comprehensive texts for teaching sanitation to non-engineering sanitary workers. This led to his first attempt to solve the text problem with the publication in 1942 of the "Sanitary Inspectors Manual". In spite of the limitations of this manual, and indeed there were many, the need for such a book was reflected in the hundreds of letters from all over the country and from many parts of the world requesting copies. The present text, while following the general pattern of the author's first manual, is in reality a new book. The material has been oriented toward sanitary practice in the United States instead of in one state; the treatment of the theory has been expanded and enriched as a result of more experience, research, and maturity; and the regulatory aspects of administration have been enlarged. The simpler types of sanitary practices, although modified by newer technology, have been retained so that the handbook could be used in lesser economically developed countries.

Texts on sanitation are beginning to increase in number and in quality. But the author of this volume feels that the need remains for a single text which will be at the same time comprehensive enough for the advanced sanitarian and sufficiently non-technical in language for the beginner. His attempt to meet this need follows almost three decades of experience in the training of public health personnel of which sanitarians constituted a large part. The text should be useful to administrators of sanitation and to industries manufacturing sanitation supplies, to plumbers, to operators of water or waste disposal plants, to food handlers and food processing industries, to administrators of various institutions, to those needing to utilize simple and emergency sanitary techniques, to teachers, to large industrial plants, and to others concerned with problems of sanitation. Administrative practices recommended are in line with existing Federal laws and with the most progressive state laws. Codes and ordinances suggested as guides are those which have been approved by such authoritative sources as the U.S. Public Health Service, the National Committee on Radiation Protection, the American Public Health Association, and the U.S. Bureau of Standards.

The author is a staff member of the Louisiana State Department of Health. He is Director of the Bureau of Health Conservation which is also responsible for Public Health Training. He has had an abundance of highly qualified consultation in developing this material. Special acknowledgment must here be made to J. A. K. van Hasselt,* former staff sanitary engineer at the Training Center, for his invaluable contributions to the chapters dealing with water sanitation, the disposal of excreta, and radiation hazards, and in drawing many of the illustrations for the book.

*Deceased.

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FOREWORD

In the past decade, greater recognition has been given to the responsibilities of the sanitarian. Enlargement of his field of duties and his placement in allied programs attest to his acceptance as a dedicated and informed individual. The sanitarian has been given greater opportunities in administrative positions, teaching and research, and in establishing public health policies and programs. He is being accepted as a professional public health colleague by his associates and by the general public.

Increasingly the necessity for educational background has been met by undergraduate and graduate students in the sciences and in public health. From the bachelor's degree, an increasing number of graduates are enrolling in the master's and doctoral programs. The former paucity of reference material for the sanitarian has been replaced by publications dealing with the multitudinous aspects of environmental sanitation.

In 1942, Dr. Ben Freedman published a manual which established him as an authority in sanitation. In 1957 the first edition of "Sanitarian's Handbook: Theory and Administrative Practice" gave a complete coverage of a sanitarian's responsibilities and the technical details required for satisfactory performance. A second edition included recent developments in this rapidly expanding area. Both editions have been widely accepted as a standard text.

This third edition includes changes that have been made in most of the chapters in order to bring the administrative data and sanitary theory up to date, particularly relating to new techniques and regulations.

Chapters on Boat and Marina Sanitation, Sanitation of Hospitals and Nursing Homes, Ragweed Pollenosis Control, and Standards for Emergency Ambulance Services have been added. The second chapter on the sanitarian's qualifications, training and interrelations has been enlarged in order to reflect the increasing professionalization of the sanitarian.

The chapter on the Microbiology of Water has been changed to the new title, "Quality of Drinking Water." Such chapters as Individual Water Supply, Seafood Control, Frozen Desserts, and Market Milk Control have been revised in accordance with newer data. The chapters on Plumbing Standards and Radiation Hazards have been brought up to date. The rules and regulations pertaining to food and drink vending machines have been considerably expanded. Food Service Sanitation has been revised in accordance with the latest U.S. Public Health Service Code. Swimming Pool Control has been brought up to date in accordance with the American Public Health Association recommendations. The information concerning new insecticides and rodenticides has been incorporated. The chapter on Meat and Meat Products has been revised in accordance with newer regulations of the Department of Agriculture.

Sanitarians in public health agencies, business and manufacturing firms, the Armed Services, and in foreign service will find this book the outstanding text dealing with detailed information on environmental sanitation. The book has had distribution in about 50 foreign countries. Universities and colleges will use it as a teaching and reference book in their educational and training courses. Those in charge of In-Service Training Programs will find it an invaluable aid for the practical application of the fundamentals of environmental sanitation.

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Chapter I

THE HISTORY OF THE SANITARIAN AND CHRONOLOGY OF EVENTS IN SANITARY HYGIENE

The Term "Sanitarian" in Historical Perspective.

Depending upon the stage of development of civil government, the term sanitarian may be defined in several ways. The general definition, however, may be stated as: "A professional practitioner of hygiene who works within the administrative framework of a community hygiene program." The sanitarian may be of a medical or non-medical background, and the position he holds may be high or low in the hierarchy of administrative responsibility.

A more specific definition of a sanitarian which is more restricted in scope, characterizes him as: "A non-medical practitioner of sanitation who works within the administrative framework of a community environmental hygiene program."

In the perspective of the historical process, the stages of development of the sanitarian are always transitional. Hence, the specific connotation in the meaning of such concepts as "professional," "hygiene," "sanitation," "administrative framework," and so forth, may be variously shaded in the successive stages of social growth. The differences must be understood as the history of the sanitarian unfolds. It should be understood also that the title, "sanitarian," came into use relatively recently, i.e., early in the 19th century, and that in the course of development of administration, various designations were given to those functionaries whose duties fell within the meaning of the definitions of sanitarian. In the United States, at the present time, a confluence of the general and special definitions more nearly describe the direction of development in the meaning of the term "sanitarian." A similar fluidity of meaning of the terms "health officer" and "sanitary engineer" apply in the historical perspective.

A comprehensive history of the sanitarian must begin at a time long before his emergence, i.e., during that period in which a sequence of events served as a prelude to his coming into being. We must begin, therefore, with man's most primitive hygienic efforts to change his environment from that crude natural state in which he originally found it. Sanitary history therefore began with man's first attempt to "build" shelter. Sanitarians, however, are primarily not builders, but regulators and educators. In consequence, they first appeared on the stage of history at the time when government began to regulate the hygiene of the environment. This apparently took place when community life was changing from tribal to civil forms, a period just before the beginning of written history.

Prehistory[1]

Before man could afford to apportion some of his labors to the problem of disease control, he had first to discover a better technology that would give him reasonable assurance of a more ample and more constant supply of food to keep body and soul together. This quest for food has been his first concern throughout most of his long history. As long as his technology was so undeveloped as to allow him only to gather or catch the naturally abounding food in his environment, he could scarcely be expected to have had much time to devote to improving his living conditions. Under such primitive conditions as prevailed in his early history, man was fortunate even to find shelter in natural caves. In the latter part of the Old Stone Age some 50,000 years ago, the technique for making fire was discovered; in addition, a more developed technology for producing stone implements brought forth an increasing ability to obtain food, and, for the first time, to dig artificial shelters. These simple changes in his existence were in reality of the profoundest significance. Man's imperceptible forward movement during the previous hundreds of thousands of years was at this point propelled into a new level of movement which culminated 35 to 40 thousand years later in the Neolithic Age. This embryonic development of his technological powers was the determining factor which changed his primarily passive role in relation to nature to that of an active participan He now began to alter his natural living conditions to satisfy his social needs. Although there is n

1. Childe, V. Gordon, a. Progress and Archeology, Thinkers Library, Watt & Co., London, 194
   b. Man Makes Himself, Thinkers Library, Watt & Co., London, 1948.
   c. What Happened in History, Penguin Books, New York, 1943.

evidence of even the most primitive type of "sanitarian" in this period, the rudimentary signs of man as "builder" came into being, as exemplified by the Gravettians of South Russia and Central Europe who built "dug houses" in the ground using skins and turf as roofs.

The urgency of man's quest for food, the essence of his life, stimulated him to observe and experiment with his environment, and resulted in the discovery of the techniques of cultivating grain and domesticating animals. The widespread use of these techniques became observable about 10,000 years ago. As the food supply became less fortuitous, more time became available for developing tools and planning ways to alter the environment, thus making possible the gradually increasing satisfaction of his basic needs. As pointed out above, a very early amenity to better living, besides more food, was the creation of artificial means of shelter. The Danubians went a step further than their savage forebears and built partially subterranean houses. Somewhat later the barbarians of Iran built huts of sun dried clay. The houses of the New Stone Age in Britain were provided with warmth and light by the burning of wood or peat in open hearths. Sleeping spaces, shelves, and cupboards built against room walls, and drains under house floors to carry off wastes from privy-like compartments were found at the neolithic settlement located at Skara Brae. Although dirt and squalor were normal conditions among these barbarians, nevertheless a process was started in living habits which contained the potentialities for a hygienic environment.

Man's growing ability to produce food, shelter, and clothing carried him from the essentially nomadic life of the Old Stone Age to the rural village life of the New Stone Age, and thence, with the discovery of metallurgy and the invention of writing, into the beginning of civilization. The civilization process was a process of urbanization which bore with it the seeds of better living and greater longevity, but also the forces for the disasterous destruction of life. The main destructive forces were the greater and greater concentration of people into crowded urban areas and the increasing necessity for travel, thus facilitation the spread of disease. Man's hygienic history in the civilized era can be recounted in terms of a chain of local, national, and international epidemics of crowd diseases that ravaged the world down to relatively recent times, and which still spread havoc in many areas of low economic development. The civilized mode of life might well have been destroyed but for the development of knowledge and the production of the means to create a salubrious environment primarily by the technique of sanitation. It was in this early history of man's transition into civilized life that the sanitarian was born in the struggle against epidemics.

The more the archeologists discover about the life of our ancient forebears, the longer becomes the history of sanitation. The desire for the fruitfulness of life made possible in the new civilized era, and the threat that crowding of population and increased travel bore to the existence of life itself forced man early to devise ways of preventing his self destruction. At the dawn of civilization, about 6,500 years ago in ancient Sumer between the Tigris and Euphrates River, there already existed at least one of the basic phases of hygienic practice necessary to cope with the crowding of urban life, to wit, the use of privies and underground drain pipes.

More than 1,000 years later and more than 1,000 miles further east in the valley of the Indus River, the technology of urban sanitation had made significant progress. Elaborate drainage networks of moulded brick were found several feet below street surface even in the area of the poorest quarters. These drains were constructed with covers of brick and stone which could be removed with ease for the purpose of cleaning. Bathrooms with house drains leading to the street drains were found to be common to the houses. In some of the two-storied houses, bathrooms and drains were found on the upper story. There were rubbish chutes or flues in the hollows of the walls leading down from the upper stories to bins. At convenient places by the roadside were public bins. Several privies were found connected to the drainage system. About the same time there existed in the houses of the upper-class in at least one town in Egypt a fine system of drainage with latrines. These ancient towns were the centers of theocratic rule which was the prevalent form of government existent in those days. Just what part of priests of the temples played in planning, building, and maintaining these sanitary facilities is not known, but from an understanding of their functions somewhat later in Egyptian life and during the biblical Hebrew theocracy, their responsibilities, it seems combined the functions of the health officer and the sanitarian in one.

Thus, the Vizier of Egypt, the priestly minister of state, as far back as 5,000 years ago had the duty each ten days of inspecting the water supply for the whole land. Of course, the Egyptian State was not very large in those early days so that the tours of inspection could have been made without too great difficulty. That the priesthood of the biblical Hebrews also had similar, if more

elaborate, hygienic functions, has been historically recorded in greater detail. Considering the fact that historical events moved relatively slowly in earlier days and that social movement was progressively slower as we recede deeper into mankind's past, it appears that the role of the biblical priest must have had its roots in the practices of the earlier prebiblical priesthood. There is evidence to believe that Mosiac hygiene was derived and assimilated by the Hebrews from Minoan, Assyrian, Babylonian, Indian, and Egyptian origins which in turn were rooted in the deeper, dimmer past.

Early Biblical Times

The Old Testament is a remarkable document[2] in that it provides a detailed codification of almost all the important hygienic knowledge that man had accumulated up to that time. The major deficiency in the Mosaic Code is that filtration, distillation, and clarification of water by coagulation although known in Egypt, were not mentioned in the Bible. However, a major virtue of the codification was that it practically eliminated from medicine and hygiene the magical practices that were so prevalent in Egyptian and other countries of that period, and it emphasized such hygienic practices as the washing of the body and personal cleanliness, the principles of isolation and contagion, the burial of excreta, the unfitness of decaying food, the safer nature of spring and well water over that of surface water, the avoidance of overcrowding, and the decontamination of fomites. The responsibility for carrying out the regulations of the code was, as already mentioned, in the hands of the priesthood which was organized in a hierarchical manner so that each person had direct and adequate supervision. The priests, besides their other religio-governmental functions, served at the same time as the medical health officers and sanitarians of the community. There was no differentiation between the functions of these two categories of public health workers.

In the general sense of the definition, the priests were sanitarians. The term medical health officer is here used to distinguish the fact that the priests were also the physicians of their people, and that they always held the executive position of leadership in the administration of public hygiene.

The "Builders" Became Sanitary Engineers[3,4]

Although the sanitarian is more directly the offspring of the medical health officer, and although the sanitary engineer has his genesis, in part, in the sanitarian, the latter's functions were markedly influenced by the work of the sanitary engineer. In part also, the origin of the sanitary engineer stems from the vocation of "builders,"--those who built of stone and brick, those who planned and directed the building of the communal houses of the New Stone Age, the temples, the privies, the tunnels, the drainage systems, and the irrigation canals at the dawn of civilization in the Indus, Euprates, and Nile valleys, the aqueducts and reservoirs of biblical Palestine and of ancient Crete and Athens. Whether the builders of irrigation systems during the incipient period of civilization were builders of a similar class who later constructed the ancient aqueducts and drainage systems is not known. Apparently, the first recorded name of such a builder was King Lucius Tarquinius Priscus (616-578 B. C.) who began directing the construction of the Roman canal system (Cloaca Maxima) early in the 6th century B. C. Whether he was the one who planned the engineering phase of this construction or was merely the one who decreed that it be built is not known, although the latter is more likely. The second recorded name of such a builder appears to be that of Eupalinus who later in that century directed a project for supplying water to Megara in Greece, and also directed the construction of a tunnel a third of a mile long through a mountain to supply water to Samos from the Leucothean Spring. The most famous of these builders is the Roman, Marcus Vitruvius Pollio who lived at the time of the reign of Augustus and was author of a celebrated work on architecture.

These early builders worked both as architects and engineers. The first evidence of sanitary specialization of this profession appeared in Rome just prior to the Christian era. The great minister of Augustus, Marcus Vipsanius Agrippa (63-12 B. C.) was appointed the first permanent water commissioner (Curator Aquarium) of Rome. Before holding this position, he was elected as an aedile in 33 B. C. He directed many public improvements in the city, such as restoring and building aqueducts, enlarging and cleansing the sewers, constructing baths and porticos, and laying out gardens.

2. Brim, C. J., Froben Press, N. Y. 1936
3. The Encyclopedia Britannica, 1940
4. Baker, M. N. The Quest for Pure Water, the American Water Works Association, New York, 1948

He was, besides having been a great statesman, the commander of the Roman fleet, a commander of an army, a governor in the East, an author, and a geographer. In 33 B.C. he built the Julia aqueduct and in 20 B.C. he completed the Virgo aqueduct. It appears that before him, the aediles were the public custodians of the water supply.

The greatest of the Roman commissioners of the water supply was Sextus Julius Frontinus,[5] a soldier, lawyer, surveyor, hydraulic engineer, and administrator. He was evidently not an architect, but he employed architects, plumbers, overseers, reservoir-keepers, line-walkers, pavers, plasterers, and other workmen to build and maintain the water system. Most of those employees were slaves. There were 15 water commissioners before Frontinus, who apparently were politicians and administrators of high position, as indeed were the aediles. Frontinus, however, had really emerged as a sanitary engineer. He was concerned about the potability of the water supply. The same year he was appointed as commissioner, 97 A.D., he published the first book on the sanitary engineering of water supplies.

The question might be asked: What was the origin of the sanitary engineer? It appears quite clear that he had his origin in the ancient profession of "builders," later to be designated as architects and engineers. These men were the builders of the Roman aqueducts. Early in the history of Rome the aediles were put in charge of supervising and maintaining these aqueducts. Later, when the position of water supply commissioner was created, some of these commissioners such as M.V. Agrippa and M. Porcius Cato also served as aediles. It appears that the hydraulic engineer, the prototype of the sanitary engineer, was a specialization resulting from the synthesis of functions of the aediles and the engineer-architects during the zenith of Rome's governmental development. These sanitary engineers had under their supervision deputy commissioners and overseers who, from the evidence available, were the sanitary water inspectors of that period. At that time 10 Roman aqueducts supplied an estimated 130 million gallons of water per day, of which 92 million were used in the city proper.

The vaulted sewer networks and the water supply systems in the medieval cities of Europe were the work of these men. Whether they were of the same profession as the men who drained the marshes upon which stand today many of the large European cities, such as Paris, is not known. Even down to relatively modern times, the sanitary engineer dealt almost exclusively with water supplies and sewage disposal, although in Britain, the Surveyor of the middle 19th century had far more extensive duties. As the work of the engineers became more complicated and extensive, it became necessary to share various aspects of the inspectional work on water supplies and waste disposal with non-engineering workers--the sanitary inspectors. Thus, although the sanitary engineer was originally a composite profession of the sanitarian (aedile) and the architect-engineer, this composite profession evolved into a specialization* of environmental hygiene and became an important influence on the course of development of the sanitarian. This interrelationship appears quite simple, but the story is actually much more involved.

The Classical Period[6]

With the decline of theocratic government and the emergence of various degrees of democracy in the slave States of the classical Greek period, medicine passed from the priesthood to the open market place. The regulation of hygienic teaching and practice no longer was the responsibility of those who governed, but became the undeclared responsibility of the individual unharnessed from group cooperation. Under such conditions, no counterpart of the priestly health officer-sanitarian existed in Greece. Although there developed a custom in Greece of appointing public medical officers for the city-state governments, these appear to have had only therapeutic functions, and to have had no relation to community hygiene practice. However, the precepts of Hippocratic personal hygiene could have been bought from the physicians by those individuals who had the means to do so, and

5. Clemens Herschel; Frontinus and the Water Supply of the City of Rome, Longmans, Green, and Company, New York, 1913, Second edition.

*The duties of the sanitary engineer as well as that of the health officer fall within meaning of the definition of sanitarian.

6. Newman, George, The Rise of Preventive Medicine, Oxford Univ. Press, London, 1932.

could have been followed only by those capable of a life of leisure. The relegation of magic to an ineffectual role in the practice of hygiene by the biblical priests appears not to have been lost to the Greek and Roman periods. Thus Hippocratic personal hygiene and Roman community hygiene were scientifically valid and effecitve instruments for better health. Greece inherited much in the knowledge of hygiene, but handed on still more. Its most important contribution was to introduce into the mind of the ancient world two new concepts, rationalism and naturalism. These fructified the empirical hygiene of the biblical period with the breath of science. The architectural-engineering science which laid the basis for the sanitation of Rome, as exemplified in town-planning, building more livable houses, supplying potable water, disposing of sewage, and draining marshly lowlands, was unquestionably Greek science. Even the appointment of "public medical officers" under the Roman empire was a practice derived from the Greeks. But it appears that these public medical officers may have had some collaborating sanitary functions with the architect-engineers, i.e., the builders, of the Roman period. To a large extent, however, their duties were confined to treating the poor, the slaves, the serfs, and the soldiers.

The Roman State was more widely organized than the city-states of Greece; its population was greater, its urban concentrations were larger. It therefore had to apply all the accumulated knowledge of the past concerning community hygiene in order to be able to grow and to maintain itself. This it did with a spendor and resourcefulness not matched again until relatively recent times. A century after Tarquinius Priscus began to construct the Cloaca Maxima, and 4 centuries before Frontinus was appointed as Rome's sanitary engineer, the Roman government created (494 B. C.) as part of its civil government, positions comparable to the non-medical health officer-sanitarian. These were plebeian magistrates called aediles, who were elected by the Concilium Plebis. The position of the aediles was, from a governmental administrative point of view, a step in advance of the biblical priest, and for the first time, a recognition of specialized functions of the non-medical administrator of sanitation. This was the first appearance of the counterpart of the modern sanitarian, or perhaps the non-medical health officer. The aediles were civil servants in the civil administration of the Roman government, in contrast to the priests who were religio-legal leaders in a tribal theocracy. The aediles were vested with authority inherent in the secular functions of the state; the priest had similar power, but of a composite nature, intermingling the secular and clerical authority. The functions of the aediles were:

1. To care for the safety and well-being of the city of Rome, including the repair and upkeep of the public buildings, sewers, and aqueducts; the regulation of traffic; the administration of precautionary vigilance against fires; the direction of cleaning and paving of the streets; the prevention of nuisances; the control of the baths and taverns; and the supervision of the public morals.
2. To care for the city's provisions, including the testing of quality and checking the quantity needed; the testing of weights and measures; and the purchasing of corn for disposal in emergencies at low prices.
3. To keep the highways clear and communications open.
4. To supervise the organization of the public games.

The Medieval Period[7]

During the medieval period, official public health practice practically disappeared. Social, economic, and political life had stagnated and regressed in certain aspects to a form of feudalism reminiscent of earlier Egyptian social decay. The distinction between public, private, clerical, and secular functions and property relations were much confounded. The level of production was low and scarcely sufficient for survival. In the earlier part of this period, the political units were generally small and weak, and governmental rule was personally administered by the rulers. The functions of government were reduced to bare essentials, and war and violence were the usual atmosphere of life. The class structure of society was rigid and the inter-relationships void of humanism. Redress for offenses was administered as private matters, while the courts, when appealed to, were mere tribunals of arbitration. The power to govern appeared as personal and private prerogatives, the lords using local agents or stewards to watch over their interests.

7. Stayer, J.R., Munro, D.C., Middle Ages, Appleton-Century Co., New York, 1942.

The medieval economy was agricultural, and the nodal point of this form of production was the village, each village operating more or less as a self-sufficient community on a low level of subsistence. The "Lord of the Manor" was the feudal chief of each settlement. The people as a whole were not free men but bondsmen, serfs, and villeins. They were bound to their manor, their activities were narrowly circumscribed, and labor was exacted from them. The village officers were the lord's officers, and the court of summary jurisdiction was his court. He was their judge as well as their employer. Poverty and squalor were the rule. Under these conditions, official public health functions were practically non-existent. The Church, however, during this period, was a force to be reckoned with.

The monasteries exerted a less direct but scarcely a less powerful influence than the manors upon the way of life and conduct of the people. True enough, they taught the pious acceptance of poverty, subservience, and obedience, and this may have exerted a tendency to disregard the squalidness of the environment and the slovenliness of behavior. But, as if pleading redemption, they also taught the elements of hygiene in a time when hygiene was dead, and emphasized cleanliness when to be clean was hopeless. They organized relief of the poor when there was no Poor Law, and they introduced books and learning when knowledge went begging in the western world. The place for the ancient priestly health officer-sanitarian, the aediles, or the hydraulic engineer had disappeared from this social system. By what means the church Councils at Orleans in 549, at Lyons in 583, at Worms in 868, and at Rome (the great Lateran Council) in 1179 attempted to restrict the free movement of lepers, and by what means Rotharius, King of Lombardy, enforced his edict of 644 A.D. providing for isolation of lepers is not historically clear, but it may be conjectured from the prevalent state of affairs, which were confused and unprincipled, sporadic, and arbitrary. Although the public bath houses became permanent institutions in medieval towns, this embryonic practice of hygiene could scarcely be considered to have been supervised by any rules and regulations having sanitary significance.

The Transition to Effective Civil Administration.

In the latter part of the medieval period, the fragmented administration of government began to centralize, and villages grew into towns and cities. This took place mainly as the result of the increase in agricultural production and the development of commerce. Along shorelines developed the city-states of Italy and the seaports of the North Sea and the Baltic. Venice was the chief center of trade with the East where plague was practically always present somewhere. Such centers of concentration of population became major sources of epidemics in the absence of elemental sanitary protection. On navigable rivers, Paris on the Seine and London on the Thames were early centers. Paris in 1329 had about 1/4 million inhabitants, and London in 1379 had a concentration of population calculated to be equal to Manhattan Island in 1905.

The elements of the administration of modern civil government, particularly the regulatory aspects, began to take root in these latter centuries of the medieval period. Police regulation, tax collection, administration of justice on the local level by county sheriffs or provincial bailli, and dispensation of justice by itinerant royal tribunals directly representing the King developed during this period. Henry I (1068-1135) and Henry II (1133-1189) of England, and Philip II (1180-1223) and Louis IX (1226-1270) of France made pioneering contributions in developing centralized state bureaucracy by establishing the mechanisms for increasing the efficiency of the administrative, judicial, and financial machinery of government. These basic improvements in government were primary requirements in order for community health regulations and programs to be able to come into existence and to be effectively administered.

Dorman B. Eaton[8], the great American pioneer of public health law, wrote in 1879 concerning the history of administrative government from the middle ages to the present era: "We are struck with the evidence, everywhere presented, that the progress made in civil administration, though having many irregularities and oscillations, has really been a sort of evolution from a narrower to a broader wisdom, from ignorance to intelligence, from injustice to justice, from a lower to a higher public morality, from the lawlessness of official caprice to the sternness of official responsibility in dealing not only with official duties in the strict sense, but with public affairs altogether."

8. Eaton, Dorman Bridgman, Civil Service in Great Britain, Harper and Brothers, New York, (Harper's Franklin Square Library, No. 220) 1879, p. 6.

The movement toward effective democratic civil administration has been characterized by the trend toward separation of state from religious functions, the replacement of law for personal rule, the differentiation of responsibility into executive and administrative, the development of competent bureaucracy in place of the "spoils system," the growth of specialization of functions, and the increasing extension in scope of police powers. The scope of police powers[9] has developed to an extent not dreamed of when their aid was first invoked. The progress of civilization and the requirements of better government for public welfare have sustained and increased these powers in number, if not in the imperial force they oft-time assume. Police powers are inherent in every sovereignty. The very existence of government presupposes the right of the sovereign power to make laws prescribing regulations demanded by the general welfare for common protection of all. Public health education, or, for that matter, public education in general depends upon the power to regulate.

The greater use of inspectors in public health began with the rapid extension in the scope of police power as modern government grew out of its feudal shell. The ancient sanitary functions of government were performed by officials closely identified with executive powers. The biblical priests, the aediles, the medieval sheriffs, bailiffs, constables, and the justices of the peace were custodians of executive power but with none or very little administrative machinery of government to aid them in the performance of their duties. They both directed and carried out the functions of their offices, though, in exigencies, with the aid of soldiers or militiamen.

In England as early as 1297, there existed legal regulations requiring every man to keep the front of his tenement clean, and in 1357 a royal order issued by Edward III required the mayor of London and the sheriffs to prevent pollution of the Thames River. In France, in 1350, King John II established sanitary police as a governmental administrative instrument. Since the time of the Roman aediles and their administrative set-up which included water supply inspectors, this appears to be the first evidence of the creation of an instrument of civil government administration in which the functions of the sanitary inspector became evident. These functions were: To keep hogs out of cities, to keep streets clean, and to prevent butchers and fishmongers from selling spoiled meat and fish.

According to Dr. Henry E. Sigerist*, the eminent medical historian, the Medieval city had, at least in the latter part of the Middle Ages, a municipal physician appointed by the city council who drew a salary, but also carried on a private practice. An example is the city of Basle, Switzerland, which has had such a municipal physician since 1355. His functions were to serve the population, rich and poor. The poor were served free in hospitals. He advised the city council as to the inspection of meat, fish, and other foods, and as to the supervision of brothels. He had to ascertain the causes of death in certain cases, and to serve on the board for the examination of lepers. He also drafted regulations in times of epidemics for the city council to issue in the form of ordinances. Thus, we have here, the reappearance of the Roman-like public medical officer who served to some extent as sanitarian as well as public physician. He might also be likened to a kind of medical health officer.

As a result of epidemic ravages, quarantine,[10] according to Scott, first appeared in Venice in 1127 when it was enacted that everyone, merchants and others, coming from the Levant had to remain in the house of St. Lazarus (lazarette) for forty days before being admitted to the city. In 1348, the Venetian Republic appointed three guardians of public health and arrangements were made to isolate vessels, persons and goods suspected of carrying infection. In 1374, entrance into that city of infected and suspected ships, travellers, or freight was denied. In 1403, a maritime quarantine station was established, and in 1448, the authorities of Venice drew up Quarantine Regulations which have served as a basis for all subsequent quarantine measures. In 1485, the Quarantine Commission was reorganized as a permanent Board of Health. This was apparently the first Board of Health ever created. Sigerist, however, believes, on the authority of Georg Sticker, that the first ordinance for establishing regular quarantine was not passed in Venice, but in Ragusa (today's Dubrovnik) in Dalmatia. There on July 27th, 1377, the city council required all individuals who came from plague-ridden countries and all contacts of such individuals to spend a month on the Island of Mercana. The

9. Prentice, W.P., Police Powers, Banks & Brothers, New York, 1894, pp. 1-11.
* Personal Correspondence
10. Scott, H.H., History of Tropical Medicine, William & Wilkins Co., 1939, Baltimore, p. 751.

isolation period of thirty days was first extended to forty days in Marseilles in 1383, and from then on the institution was called quarantine.

Whether the enforcement agents of the quarantine were medical or non-medical, or just when the medical profession began to be employed as public health officials with police power over the environmental hygiene of the public is not clear. If the enforcement agents were non-medical, they might very well be comparable to latter day non-medical health officers or sanitary inspectors.

The Renaissance[11]

The 15th and 16th centuries were characterized by the quickening of social movement during which the dying Middle Ages gave way to the modern period of the revival of learning, of increased growth of science, art, and the technology of production, of commerce and industry, of travel, geographical discoveries and colonization. Concern about human welfare gained momentum at a rate parallel to the growth of industrial production and of urbanization. The increasing commercial traffic favored the spread of disasterous plague epidemics over Europe. Quarantine laws and regulations became the most important public health administrative tools of control of epidemic disease.

First among the nations to manifest an accelerated process of industrilization and urbanization was England. As the towns grew, the housing facilities became over-crowded, filth accumulated, the sick, the poor, and the pauperized became concentrated in slums, the rivers and streams became highly polluted, and starvation and epidemics raged unmercifully. Before Queen Elizabeth's reign, the indigent and sick were cared for by the various local corporations that existed within the church, such as hospital foundations, almshouses, and the service provided by monastic establishments. In 1601, following the Reformation which took away much of the church's wealth and destroyed the monasteries, the British crown assumed control by means of the Poor Law Act, which has since been added to and modified for 350 years into the great health and welfare system of Britain.

During the Renaissance, the administration of public health was, to a large extent, a continuation of the pattern of the latter centuries of the Middle Ages. The non-medical sanitarian, as we understand him today, did not exist. Agents of the government and the church, however, served in the role of sanitary officers where circumstances required, but, with few exceptions, not as specialists in the field of sanitation. Those vested with police power were responsible for the execution of the health laws, ordinances, and regulations. For example, in the series of Plague Orders for controlling the spread of plague in England (the first of which was promulgated in 1543), the mayors and alderman of the cities, the justices of peace of counties, the physicians, church-wardens, ministers, curates, overseers, constables, marshalls and assistances, watchmen and other hired men carried out the administration and operation of the Orders. At Bordeaux, France, the captain of the plague, the ward alderman, surgeons, the masters of houses where plague occurred, and the neighbors of such houses were required by law to carry out control measures against plague. Similar measures against plague were passed in Venetia and Lombardy in 1534, known as the Sterzing Ordinance. This pattern was also transplanted to the American colonies for the control of epidemics.

Thus, plague was the great teacher of the nature of communicable diseases during the Renaissance, and also served as the stimulant of public health law and administrative techniques. The growth of strong central government made control efforts more effective than in the past. Government regulation of industry and many other phases of social life was the accepted order of things. Under such regulated regime, various sanitary and welfare laws were initiated and progressively developed for relieving the hazards of life. In Queen Elizabeth's reign, housing plans were proposed to relieve overcrowding, pure food laws were passed, rules were made to keep streets clean, and laws were passed for controlling epidemics.

One of the important outgrowth of this period was the initiation of specialized administrative commissions to deal with public health problems. These commissions were the forerunner of modern Boards of Health. Thus, early in the 15th century, Henry VI established a Commission on Sewers for preventing the pollution of streams. Later in this century, as already mentioned, Venice organized a permanent Quarantine Commission. In 1518, Henry VIII created the College of Physi-

11. Public Health in Tudor England, Sanford V. Sarkey, American Journal of Public Health, Vol. 24, p. 1099, November, 1934.

cians on advice of his physician, Thomas Linacre, the great humanist and "restorer of learning" in England. This College was given the authority of a Board of Health, and it played a prominent role in drafting regulations for the control of epidemics in England. The men of this group who participated in these activities might well be considered the first public health physicians of England, or more aptly, the first medical sanitarians of the country. They were responsible for drafting the first London Plague Orders and for stimulating the Privy Council to adopt a measure for collecting vital statistics for the first time (1532) in the form of "Bills of Mortality." At this point, one is forced to speculate whether any of the ancient Roman collegia may have had similar functions in health administration as the College of Physicians. This will require further research.

By the end of the Renaissance, a number of European port cities had Health Commissions whose main function was quarantine, but who also carried on other functions of sanitation believed necessary in controlling epidemics. Although drabness and squalor were universal in the growing towns of the 16th century, indications are that the towns of this period were cleaner and that conditions were more sanitary than later during the first century after the beginning of the industrial revolution. During the latter period, crowding and slums became intolerable and mortality rates increased significantly. The accelerated governmental interest in community health and welfare under Queen Elizabeth, the extensive schemes for city planning of both James I and Charles I, and similar humanistic efforts in other European countries waned and were discarded in the wake of the industrial revolution. These occurred because of the vigorous opposition from selfish private interests as the laissez-faire system gripped the western world. But the protests from scholars and statesmen did not cease, and their efforts laid the basis for the Great Awakening.

The Great Awakening[12, 13]

The development of the idea of medical police* was greatly stimulated in the latter part of the eighteenth century by the labors of Johann Peter Frank (1745-1821), who was the brightest harbinger of hygienic community life on the European continent in the wake of the humanistic ferment of the Renaissance. His worthy successor in this role was Max von Pettenkofer (1818-1901), who was the last great environmental hygienist to base his control practices on non-bacteriological theories. In the restricted sphere of the British army, Sir John Pringle (1707-1782) introduced sanitary measures as routine for the soldiers on the battle field and in cantonments, while Dr. James Lind (1716-1794) did the same for the British Navy. Dr. John Roberton of Britain wrote a systematized treatise on medical police (1809), leaning heavily on the teachings of Pringle and Lind but applying this knowledge to civil administration. The modern sanitary era was championed and found its leadership primarily in physicians, who up to very recent times were proud to be called sanitarians to distinguish them as practitioners of disease prevention and control. Although most sanitarians of the pre-bacteriological period were physicians, there were indeed many lawyers, engineers, architects, and businessmen who also had a consuming interest in community hygiene, can legitimately be called "sanitarian". Some of the more eminent of these non-medical sanitarian pioneers were William Farr, Edwin Chadwick, and Lemuel Shattuck. The medical sanitarian was the paractitioner of hygiene around whom the public health movement rallied.

Subsequent to the evolution of the medical sanitarian,[14] another non-medical type, designated as inspector also came into being. Market Inspectors were maintained in most American cities from the beginning of the modern sanitary era. The New York City Council, in 1804, 3 years before the establishment of its Board of Health, appointed a City Inspector. By the mid-century, that city employed a number of health wardens. Boston, in 1859, appointed a Milk Inspector to enforce a regulation against the use of distillery slop for feeding cattle. In 1873, the city of Washington employed a Dairy Inspector, and around the same time, a number of cities were employing Plumbing Inspectors. Police Inspectors were entrusted with enforcing the child labor law and with inspecting factories and

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12. Winslow, C.E.A., The Evolution and Significance of the Modern Public Health Campaign, Yale University Press, New Haven, 1935.
13. Walker, M.E.M., Pioneers in Public Health, Oliver and Boyd, London, 1930.

* This term refers to the systematization of public health which began in the 18th century and was distinguished by the fact that the physicians began to play a leading role in public hygiene by the application of epidemiological theory to the administration of public health.

14. A Half Century of Public Health, edited by Ravenel, H.P., American Public Health Association, New York, 1921.

public buildings in Massachusetts beginning in 1866, and in 1905, health department inspectors replaced these police inspectors. By 1884, the Province of Quebec employed 160 sanitary inspectors. By the turn of the century, many large American cities employed as many as 200 sanitary inspectors to deal with nuisances. The term, Sanitary Inspector, apparently came into use about the middle of the last century. It appears that many cities had such inspectors. Consequent to the laws which established modern public health administration in Britain (Public Health Act, 1848; Local Government Act, 1858; Sanitary Act, 1866; and Public Health Act, 1872.) there came into existence the Inspector of Nuisances whose duties were quite extensive and even comparable to present day inspectors in some parts of the United States. In some places in America and Europe, the term inspector was being applied also to medical sanitarians during the development of public health in the 19th century.

As commerce and urbanization developed, so did the fierceness and destructiveness of epidemic diseases. This was the great problem of the physicians of the pre-bacteriological period. Therapeutically they were completely helpless to combat the ravages of these communicable diseases. Most American physicians of respectable standing were interested in prevention and control. The only disease for which an instrument of prevention was available was smallpox, and even this was not universally accepted by the profession. Nevertheless, the theories of contagion or miasmatic effluvia having been widely accepted, directed the physicians into seeking environmental control measures. The physician was therefore forced by lack of therapeutic knowledge to turn toward the more fruitful saver of life, public health, and in particular, environmental sanitation. He directed quarantine and isolation operations, inspected slums and nuisances, planned drainage programs, perfected fumigation procedures, supervised food control operations, and the like. The increasing population concentrations and commercial transportation, the growth of knowledge of control and prevention of disease, and the higher value placed on human life forced governments to extend their regulatory activity in environmental hygiene. With physicians mainly composing the executive positions as health officers and members of boards of health, the need for field workers in the administrative organization of health departments increased. For helpers in such regulatory work, the physician was directed to employ non-medical workers, the various types of sanitary inspectors. The medical and non-medical inspectors became cornerstones early in the modern public health movement. With the development of the knowledge of prevention, control, and public health administration, the medical sanitarian took on the title of health officer, and the non-professional sanitary inspector began to grow into a professionalized sanitarian.

Professionalization of the Sanitarian

What is the meaning of the phrase "professionalization of the sanitarian?" The term sanitarian has always had the connotation of professionalism, particularly because most sanitarians of the nineteenth century were physicians. The relatively recent appropriation of this term en masse by the non-medical public health specialists, the sanitary inspectors, is a new phase of the latter's development. This new phase is the transitional period of the technician's aspiration to professional status.

Characteristics of a Profession as presently understood:

1) Its motivations are altruistic and its objectives are primarily to render a community service rather than to compete for material gain. 2) Its members deal mostly with people rather than things, or with things that are of primary importance in the basic affairs of people. 3) Its services are essential to the well-being of the community. 4) Its members possess a high degree of expertise in some specialized field, requiring a high degree of training as specialists. 5) It is identified by the adherence of its individual members to an ethical philosophy of deportment and practice solidly established by tradition. 6) The educational and training standards are formally recognized and provided through a period of intensive study, usually in professional schools, colleges, or universities. 7) Its members are committed to a life of continual professional development by study and investigation. 8) It is dedicated to develop the body of clearly defined knowledge, attitudes, and skills by which it practices, and to share this knowledge unreservedly for professional growth so that the community may be better served. 9) It is identified by its high regard for research and a disciplined orientation in the analysis and evaluation of new information before accepting it into its own body of knowledge. 10) It has available to it textbooks and journals specifically written for and, to a large extent, by its members, and directed toward the edification and development of the proficiency of its

members. 11) Its status and qualifications are recognized usually by legislative act. 12) Its members have a socially recognized freedom to act professionally, crystallizing their authority in a legal recognition of their competence. But this authority is counter-balanced by the grave self-conscious responsibility of each individual and of the group as a whole for the conduct of their actions. 13) Its members are associated in an organization which holds meetings, workshops, conferences, and publishes professional literature.

The history of the Sanitarian has been long and honorable. His roots from the beginning have been in the professional life—the life of service to the community. He is an offspring of the physician. In ancient times he participated in the genesis of the sanitary engineer and has since then received nourishment from the latter. He has been nurtured in the atmosphere of regulatory power and is now maturing in the school of public health education. He has almost attained a professional status following in the footprints of his medical forebears. That he will attain such status is a certainty. The length of time it will take for his final coming of age will depend upon the length of time it takes the non-medical sanitary technologists to meet the criteria of professionalism. Since the conditions necessary for success now exist, the sanitarians are now the masters of their own fate.

Important Dates in Sanitary History

Circa 4500 B.C. Privies were used at dawn of Civilization in Sumer.
Circa 3000 B.C. Drainage system lined the streets of city of Mohenjo-Daro in the Indus Valley, and in the city of Kahun in Egypt.
Circa 3000 B. C. Mosaic Code of Hygiene developed.
Circa 2800 B.C. Water pipes, bathrooms, and water-closets with waterpan for flushing was used in Crete.
Between 3000 B.C. and 2000 B.C. Filtration, distillation, boiling, and clarification of water was known to the Egyptians.
720 B.C. Sargon II had an aqueduct built to bring water to the town of Khorsabad (Assyria.)
590 B.C. Tarquinius Priscus began canalization of Rome (Cloaca Maxima.)
532 B.C. Eupalinus of Megara tunnels water supply of Samos from Leucothean Spring.
494 B.C. Aedeles (sanitary police) in Rome.
312 B.C. First Roman Aqueduct built (Aqua Appia-11 miles long.)
100 B.C. Central heating in Rome.
18 A.D. Roman Baths (thermae) opened by Vipsanius Agrippa.
Circa 50 A.D. Athenaeus of Attilia, writing on Purification of Water, cites a single, double, and triple filtration process as producing water of the greatest purity.
Circa 77 A.D. Pliny describes for the first time the use of lime and aluminous earth as precipitants in water treatment.
97 A.D. Sextius Julius Frontinus was appointed water inspector (Curator aquarium) in Rome, and he published the first book on water supplies entitled "De Aqueductibus Urbis Romae."
583 Council of Lyons interdicts the migration of lepers.
643 Edict of Rotharus, King of Lombardy, referred to compensation for injuries of employees on the job.
644 Edict of Rotharus, King of Lombardy, for segregation of lepers.
1183 Paris constructed an aqueduct to supply water to the city.
1235 Conduits and lead pipe systems built to bring spring water to the inhabitants of London.
1273 The first smoke abatement law was passed in England prohibiting the use of coal in London as being prejudicial to health.
1281 Guildhall order forbidding swine in the streets of London.
1297 In England, regulations were passed for keeping fronts of houses clean.
1311 Guildhall order forbidding flaying of dead horses in London.
1343 Report on faulty sanitation (nuisances in London White Book-Liber albus.)
1345 Pollution of the Thames River began to receive official attention.
1348 Board of Health and quarantine established at Venice.
1350 In France, the first sanitary police program was established since the time of the Roman Aedeles.
1357 Royal order against throwing filth into the Thames (London.)
1371 Royal order forbidding slaughtering of animals in London and suburbs.

1377 At Ragusa (Dalmatia), the first quarantine ordinance was put into effect.
1388 First English Sanitary Act (Richard II.)
1403 Quarantine lazaretto at Venice.
1415 Ordinance by Henry V against extra-mural nuisances in London.
1473 Ulrich Ellenbog publishes tract on poisonous gases and fumes.
1486 Statute by Henry VII regulating slaughter houses.
1495 English statute by Henry VII against contagion by fomites (bedding.)
1496 Bathing in common prohibited at Nuremberg.
1513 First health ordinances passed in New World occurred at Santo Domingo.
1518 Nuremberg ordinance regulating sale of food.
1519 First quarantine established in the new world at Santo Domingo.
1524 First ordinances for control of human excreta and slaughter houses in new world issued by Cortez for Spanish colonies.
1527 First pumps for water supply installed in Germany; London followed in 1582.
1532 Act of Parliament (Henry VIII) instituting Commissions on Sewers in England.
1543 Water supply and sewage plant (with farm) at Bunzlau (Silesia)
1546 Georg Agricola describes ventilation of mines.
1558 Luigi Cornaro publishes treatise on personal hygiene.
1593 Elizabethan Act against overcrowding of London houses.
1596 Sir John Harington, in his book "The Metamorphosis of Ajax" described the first modern valve water-closet which flushed mechanically from a tank.
1599 City of Vienna, Austria, prohibited the sale of milk, butter and cheese for a time because of an epidemic which was believed to have originated from these products.
1610 In the Virginia colony, the first hygiene law was established in North America.
1624 Louis Savot improves the fireplace (inside air and flue.)
1631/32 The General Assembly of Virginia enacted a law to collect vital statistics.
1647/48 Massachusetts passed a temporary quarantine law.
1659 Athanasius Kircher, in Germany, observed bacteria in milk for the first time.
1683 Leeuwenhock describes and figures bacteria.
1692 Nuisance legislation was passed in Carolina and in Massachusetts.
1704 Slaughter house regulations passed in Massachusetts.
1712 The General Assembly of Carolina created the first position of "State Health Officer" in North America.
1730 The sales of meat from tuberculous cows was forbidden in Munich.
1743 Paris, France, passed a milk ordinance which was intended to regulate the keeping of cows and goats for milk.
1750 Benjamin Franklin, in Philadelphia, organized the first street cleaning Department in North America.
1757 James Lind's Treatise on naval hygiene published.
1761 The first steam driven water pump was installed in London.
1762 Boisseau suggested chemical treatment of sewage.
1762 Marcus Anton Von Plenciz, Sr. in his tract on scarlatina advanced the idea of a Contagium Animatum, with a special seminium verminosum for each disease in man, animal, and plant.
1774 The first Board of Health in the new world was created in Guatemala.
1774 The Prison Reform Laws were passed for sanitating prisons in England.
1783 The Berlin Board of Health passed regulations for meat inspection.
1786 Regulations were passed in Austria regarding protection of factory apprentices.
1789 The French revolution abolished oppression of apprentices.
1793 The first local Board of Health in the United States was created in Baltimore.
1797 Massachusetts passed a law allowing local boards of health to be established.
1798 The United States Public Health Service was established.
1799 Johann Peter Frank, the great German sanitarian, published his work on public hygiene.
c. 1800 Guyton de Morveau in France, and Cruikshank in England first used Chlorine to treat water.
c. 1800 Thomas Henry in England proposed the use of lime for water softening.
1802 Parliament passed the first British Factory Acts for making working conditions more hygienic.
1806 In France, legislation was passed regarding hours of beginning and stopping work.

1810 Nicholas Appert of France discovered the canning process for preservation of food.
1810 Peter Durand developed the use of tin coated steel containers.
1813 An Imperial decree was passed in Belgium prohibiting children under 10 years from working in mines.
1819 Report of a Committee of the Parliament of Great Britain stated that evidence bore out the practicability of smoke prevention.
1820 Commercial canning began in America.
1821 William Underwood, in New Orleans, introduced the food canning process to the U. S.
1824 A patent was issued to Valaver for a machine in which dry air was passed over water thus extracting the heat by evaporation.
1827 Chlorinated solutions were being used in France for disinfecting the hands as an important adjunct in treatment of hospital gangrene.
1829 James Simpson introduced filtration for the London Water supply for esthetic reasons.
1832 A Federal Act was passed making funds available to aid State quarantine activities.
1833 The Comprehensive Factory Act was passed to protect the health of industrial workers in Britain.
1834 Dr. Robley Dunglinson recommended the use of chlorination for making marsh water potable.
1836 Massachusetts passed an Act providing for every working child under 15 years to have 3 months schooling during working year.
1839 An Act was passed in Germany regulating the employment of young persons in factories.
1841 Dr. Thomas Clark used lime in Scotland for large scale softening of water.
1842 The Poor Law Board, headed by Edwin Chadwick, made its report entitled "Sanitary Conditions of the Labouring Population of England."
1844 Dr. John H. Griscom wrote his famous letter entitled "The Sanitary Conditions of the Laboring Population of new York."
1847 Klencke stated that there is a positive connection between milk of tuberculous cows and tuberculosis in children.
1847 The Ten-Hour bill was passed in Britain.
1848 Pennsylvania passed a child labor law.
1850 Lemuel Shattuck issued his report entitled "Report of the Massachusetts Sanitary Commission."
1850 Carre discovered the ammonia-absorption process for refrigeration.
1851 Dr. J. C. Simonds issued his paper on "The Sanitary Conditions of New Orleans."
1852 Massachusetts passed a law regarding safety of steam machines.
1854 Dr. E. H. Barton issued the New Orleans sanitary commission's report on the yellow fever epidemic of 1853.
1854 A milk law was passed by Massachusetts prohibiting adulteration of milk.
1854 An English Commission used chlorination in the treatment of sewage in London.
1855 Louisiana established the first State Board of Health in the United States.
1855 Dr. John Snow published his book on the sanitary conditions relating to the spread of cholera in England in 1848-49 and 1853-54, and the epidemiological proof of its water-borne nature.
1856 State of Massachusetts adopted a law with intention of prohibiting the sale of adulterated milk.
1859 A milk inspector to enforce a regulation against feeding distillery slop to cows was appointed in Boston.
1860 The first English milk law was passed prohibiting watering of milk.
1860 G. F. H. Kuchenmeister recommended the use of carbolic acid as a general disinfectant.
1860 E. A. Parkes was first to hold a professorship in hygiene (at Army Medical School, England.)
1863 Washington D. C. passed a law declaring unsanitary cow yards a nuisance.
1863 Louis Pasteur demonstrated the process of pasteurization.
1864 E. A. Parkes described sanitary privies, water closets, and latrines in his "Manual of Practical Hygiene.
1865 Joseph Lister was using carbolic acid for dressing wounds and for disinfecting surgical instruments.
1865 Max Von Pettenkofer was made professor of the first Institute of Hygiene, at the University of Munich.

1866 A large dairy company of London voluntarily adopted sanitary regulations for control of dairy farms.
1866 The great Sanitary Act was passed in Britain, thru the efforts of Dr. John Simon, which gave adequate power to the health authority to carry out sanitary control measures.
1866 The Metropolitan Health Act was passed in New York through the efforts of Dr. Stephen Smith and Dorman Eaton giving adequate power to the health authority to enforce the public health laws.
1866 W. Griesinger showed that hookworm disease was caused by the worm, Ancylostoma Duodenale.
1868 Edward Frankland in England recommended intermittent filtration of water through sand filters.
1870 The use of steam under pressure for sterilization became practical.
1870 Louisiana organized the first State Board of Health chemical laboratory.
1871 J. P. Kirkwood designed the first water filtration plant in the United States at Poughkeepsie, N. Y.
1871 Burdon Sanderson demonstrated the presence of bacteria in water.
1872 Louisiana State Board of Health appoints first official public health chemist in the United States.
1872 The American Public Health Association was founded.
1873 Dr. William Budd wrote his famous book "Typhoid Fever, its Nature, Mode of spreading, and Prevention."
1873 Jacobi of New York seems to have been the first health expert to recommend the heating of cows' milk. He recommended that milk for infant feeding be put into baby feeding bottles momentarily heated to 212° F.
1874 Fryer builds furnace incinerator for refuse at Nottingham, England.
1875 Alabama laws provided board of health representation in rural areas for first time in United States.
1875 Pure Food Law passed in England, the first in modern times.
1876 Passage of the British Pollution Prevention Act to protect British streams.
1878 Sir Patrick Manson discovered the transmission of filariasis by the culex mosquito.
1878 Mississippi created first permanent county Boards of Health.
1878 U. S. Public Health Service was given authority to take on Quarantine duties.
1878 The Factory Consolidation Act was passed for protecting the health of industrial workers in Britain.
1879 Louisiana State Board of Health placed quarantine intelligence officers in foreign ports for the first time in public health history.
1879 The National Board of Health was created by the Federal Government. This agency went out of existence in 1893.
1880 Pierre Miquel devised the first exact method for enumeration of bacteria in water.
1880 Milk was being pasteurized in a small way by commercial concerns.
1880 Carlos Finlay described the relationship of the Aedes aegypti mosquito to yellow fever transmission.
1881 Chicago passed the first smoke regulation ordinance in the U. S. in April, and Cincinnati followed in November.
1881 The Alkali Act was passed in Great Britain to regulate pollution connected with the production of superphosphates.
1881 Hart compiled and reported a long list of milk epidemics, furnishing convincing evidence of relationship between milk and disease.
1881 Robert Kock introduced the solid culture media method for growing bacteria.
1881 New York State enacted first effective Food Control Laws in the United States.
1882 Koch discovered the tubercle bacillus.
1882 Newark N. J. authorized the inspection of dairies.
1884 Workman's Insurance began in Germany.
1885 P. B. Frankland adopted Koch's method to enumerate bacteria in sanitary practice.
1885 Reilly of the U. S. Army built the first garbage incinerator in the United States on Governor's Island, N. Y.
1886 The first America garbage reduction plant was built in Buffalo, N. Y.
1886 A. F. Spawn, an American, used regulated mechanical processes for drying all kinds of fruits.

1886 Franz von Soxhlet in Munich recommended that all cows' milk fed to infants be boiled or sterilized to kill bacteria.
1888 The U. S. legislature passed a law prescribing an 8 hour day for mail carriers.
1888 Dr. G. T. Swarts operated the first local board of health bacteriological laboratory in the United States for examination of water supplies. This was not a diagnostic bacteriological laboratory.
1889 The first milk bacteriology was done in the United States by Conn.
1890 Babcock introduced his method for determining percentage of butterfat.
1890 Bitter reported that by heating milk for 30 minutes at 154° F., the process was sufficient to thoroughly pasteurize the milk. He built first pasteurizer with spiral coil.
1890 Kock discovered tuberculin which is used in testing cows.
1890 U. S. legislature passed several child labor laws relating to mines and sea service.
1891 Fermentation of stored sewage (septic tanks) was developed by Sir Colin Scott-Moncrieff with the British Foreign Service; in the United States, by A. N. Talbot (Illinois) in 1894.
1892 Henry Leber Coit inaugurated the movement toward certified milk.
1892 William Joseph Dibdin, in London, initiated the development of contact beds.
1892 The trickling filter was introduced for sewage treatment by Lowcock, England.
1892 The first bacterial counts on milk in U.S. were made by Sedgwick and Batchalder in Boston.
1893 Dr. Herman Biggs organized the first local Board of Health Diagnostic Bacteriological Laboratory in the United States.
1893 Theobald Smith described the relationships of the tick to cattle in transmission of Texas Tick fever.
1894 The Louisiana State Board of Health established the first State Board of Health Diagnostic Bacteriological Laboratory in the United States.
1894 A. Yersin established the fact that rat plague was the same as human plague.
1895 A. Looss showed that hookworm entered the body by way of the skin.
1897 Sir Ronald Ross discovered the transmission of malaria by the Anopheles mosquito.
1898 P. L. Simond of Spain showed that bubonic plague was carried by the rat flea.
1898 Theobald Smith differentiated bovine from human type tuberculosis.
1899 Sir Ronald Ross demonstrated that malaria could be controlled by mosquito control.
1899 B. K. Ashford found hookworm eggs in the stool.
1900 Karl Imhoff (Germany) devised the sewage treatment tank known as the Imhoff Tank.
c. 1900 Professor Ringelmann in France developed the "Ringelmann Chart" for evaluating the density of smoke emission.
1901 Walter Reed proved Finlay's theory that yellow fever is transmitted by the Aedes Aegypti mosquito.
1901 W. C. Gorgas demonstrated that yellow fever and malaria could be controlled by mosquito control.
1903 Stocking showed the advantages of small-mouthed milk pails to keep dirt out.
1904 A commission showed that anemia in the rural areas of the United States was due to hookworm, and that lack of excreta disposal facilities was the most important reason for spread.
1906 Federal Food Laws enacted in the United States.
1906 Texas cattle fever prevention program began by Federal, state and local collaboration which eradicated the disease.
1908 The federal government passed a limited workmen's compensation law.
1908 Jefferson County, Kentucky, established first full-time county health unit.
1908 The city of Chicago adopted the first ordinance requiring the pasteurization of all milk except milk of the highest sanitary quality.
1908 First large scale use of chlorination by the Jersey City Water Works.
1909 The Rockefeller Commission was established to rid the South of hookworm.
1909 The U. S. Bureau of Mines began its investigation of hygiene and safety in mines.
1910 Stiles and Lumsden described the first American type sanitary privy.
1910 Publication of the first edition of Standard Methods for the Examination of milk by the American Public Health Association.
1911 Guilford County, North Carolina and Yakima County, Washington established rural health services on a county unit bases.
1911 National Safety Council was established.
1912 N. Y. City adopted the first milk grading system.
1912 Robeson County, North Carolina established the first strictly rural county health department in the United States.

1912 Children's Bureau was established.
1912 The Division of Industrial Hygiene was created in the U. S. Public Health Service.
1914 W. T. Lockett discovered the activated sludge process.
1914 The U. S. Public Health Service began its studies on typhoid fever in rural areas.
1916 Congress appropriated its first $25,000 for rural sanitation.
1920 Vocational Rehabilitation Act passed in the United States.
1924 The first U. S. Public Health Service Standard Milk Code was published.
1931 First issue of the journal, The Sanitarian.
1935 Social Security Act passed establishing Social Security Board.
1935 Railroad Retirement Act passed in the United States.
1937 National Housing Act passed in the United States.
1937 Creation of the National Association of Sanitarians.
1938 Fair Labor Standards Acts passed in the United States.
1938 Enactment of the Federal Food, Drug, and Cosmetic Act which added new provisions to the old Act in order to meet the need for consumer protection under current conditions.
1943 Barden-La Follete Act extending the provisions of the Vocational Rehabilitation Act of 1920 was passed.
1945 California passed the first bill for the registration of Sanitarians.
1953 Federal Security Agency was given cabinet status and became the Department of Health, Education, and Welfare being composed of:
United States Public Health Service
Population and Vital Statistics sections of the Census Bureau
Food and Drug Administration
Office of Education
Office of Vocational Rehabilitation
Social Security Administration under which is the Children's Bureau.
Institutions such as Howard University and St. Elizabeth's Hospitals.
1958 Food Additive Amendments (of the Federal Food, Drug, and Cosmetic Act) Act was passed to protect the public in safe use of food additives by requiring proof of safeness.
1959 Enactment of the Federal Poultry Products Inspection Act providing for inspection and approval of poultry and poultry products for wholesomeness.
1960 Report of the Panel on Food Additives of the President's Science Advisory Committee on the safety and quality of the United States' food supply.
1960 Color Additive Amendments was enacted to protect the American public when color additives are used in or on foods, drugs, and cosmetics.
1960 Federal Hazardous Substance Labelling Act was passed to regulate the distribution of sales of hazardous substances intended for household use.
1961 Report of the Committee on Environmental Health Problems (Gross Report) for developing long range objectives for environmental health programs of U.S. Public Health Service.
1961 Housing Act was passed to reduce urban blight and congestion, to improve housing in the United States for the low income and moderate income families, and to stimulate urban renewal and planning and beautification.
1962 Enactment of Drug Amendments Act for protection of American public in the safety, effectiveness, and reliability of drugs, standardization of drug names, and strengthening of inspection authority.
1962 Public Works Acceleration Act was passed to accelerate the development of local water supplies, sewerage systems, street and sidewalk projects, hospital construction and anti-pollution programs in the United States.
1965 Creation of the U.S. Department of Housing and Urban Development whose functions relate to the general welfare, health, and living standards of our people and beautification of urban areas.
1965 Passage of Economic Development Act for long-range development of areas of unemployment for low income families in the United States.
1965 Passage of the Federal Clean Air Act Amendments (of 1963 Clean Air Act) and Solid Waste Disposal Act to provide important tools to help develop a comprehensive attack on the growing national problem of community air pollution.
1965 Passage of Medicare or Social Security Amendments Act of 1965 which established health insurance for the aged and made same possible for all age groups in the United States.
1965 Passage of the Water Quality Act, and the establishment of the Federal Water Pollution

Control Administration in the Department of HEW which was transferred to Department of Interior in 1966.

1966 Creation of Committee (by Executive Order) to advise President's Council on Recreation and Natural Beauty on matters relating to outdoor recreation and the beautification of cities and countryside in the United States.

1966 Enactment of National Highway Safety Act requiring each State in the United States to develop an approved highway safety program designed to meet the performance standards for highways by the end of 1968.

1966 Enactment of the Comprehensive Health Planning Act which made possible for the first time the development of comprehensive health services for all people in the United States and the defragmentation of community health services.

1966 The U.S. Department of Transportation was created.

1966 Creation of the American Intersociety Academy for Certification of Sanitarians to give special recognition to professional sanitarians who have and are demonstrating a high degree of ability, competence, and leadership.

1967 Establishment of the National Center for Urban and Industrial Health, including Water Supply and Sea Resources Program.

1967 Reorganization of the U.S. Public Health Service which created the Bureau of Disease Prevention and Environmental Control.

CHAPTER II

THE SANITARIANS'S QUALIFICATIONS, TRAINING, AND INTERRELATIONS

Who is the Sanitarian of Today?

Sanitary science includes not only the knowledge of prevention and control of preventable diseases by environmental control measures, but also the knowledge of achieving standards of living necessary, economically attainable, for the physiological needs of people in their particular environmental setting. The individual scholastically trained in this science is a professional sanitarian.

The non-medical sanitarians and sanitary inspectors with whom we are concerned in this book as distinguished from the medical sanitarian who predominated in the 19th century are primarily occupied with enforcing laws, rules and regulations for maintaining community health, although they are more and more orienting themselves to achieve their ends by education, enlightenment, and persuasion. The sanitary engineers are more concerned with the development of sanitary standards and regulations for the technical aspects of designing, construction, and supervision of operators of various facilities and techniques which are conducted toward the improvement of the living condition of communities.

If, in accordance with sanitarians themselves, we define the term, "sanitarian"[1] as "a professional person qualified by education and experience to control environmental factors for the optimum health and comfort of mankind," then, only a relatively moderate proportion of those who call themselves sanitarians qualify to be so designated. If, again in accordance with the contention of sanitarians, we define a profession[1] as a group "recognized by the specific and unique body of knowledge it embraces and the application of this knowledge by members of the profession," then plumbers, carpenters, pipe fitters, welders, and the like trades are all professions. The American Medical Association's concept of a profession is much more fundamental: "A profession has for its prime object the service it can render to humanity; reward or financial gain should be a subordinate consideration. The practice of medicine is a profession. In choosing this profession an individual assumes an obligation to conduct himself in accord with its ideals."[2] Other basic criteria of a profession are given in the preceding chapter on the History of the Sanitarian. Whether the sanitarian be classified as professional depends on the actions and aspirations of all those who call themselves and are recognized as sanitarians. Many sanitarians operate, indeed, on the level of the professional.

Sanitarians and lay health officers have played an important role in administration of regulatory enforcement in the process of public health development. The sanitarian has, indeed, one of the oldest and proudest histories of all public health personnel. That public health today is, for the most part, no longer directed by lay people is a fine commentary on its growth and development. Its leaders today are scientists in every professional field. Medical men have become the health officers. The sanitarian, reinforced by the technology of the sanitary engineer and fortified with the physical, chemical, biological, and social sciences, has broadened his perspective and multiplied his functions.

Water supplies and excreta disposal must be controlled; the handling of milk, meat, and other foods must be supervised; building construction, lighting, heating and ventilation inspection is a job needing continual vigilance; mosquitoes, flies, and other insects must be abated; rat control measures must be directed, and in newer fields, such as relate to accidents, radiation hazards, air pollution, urban planning, air pollenosis, slum clearance and neighborhood development by application of social dynamics, environmental disasters, must come into the working pattern of community control activities. The field work necessary to maintain such control measures is interminable. White collars cannot always be worn to do the job on the spot. The highly specialized sanitary engineers are few and their talents are best used in directing and developing the technological engineering aspects of sanitation. It falls upon less technologically oriented, but well educated sanitarians to carry on the educational, public relational, inspectional and investigative aspects of this field work.

1. Report on the Disaster Capabilities of Sanitarians with Special Reference to the Academic Preparation of this Professional Group, Denver, Colorado, May 2-4, 1962.
2. AMA Bulletin, Vol. 31, No. 5, May 1936, p. 95.

The inspector or sanitary inspector is a term applied to a non-professional, relatively little trained layman who makes routine inspections of places when nuisances are reported, and regularly inspects certain public places where health hazards are likely to occur. Sanitarian assistant is a term used by the American Public Health Association to designate this type of worker. Sometimes, the terms sanitary officer and sanitation officer are used to designate the sanitary inspector. Science has so enriched our understanding of sanitation that every entity in our environment has come under the scrutiny of public health, and consequently, the inspector is being forced more and more to become professionalized. His required knowledge and his work have been changed, and he who has progressed with these changes has had his titled changed to sanitarian.

The National Association of Sanitarians is a powerful instrument in speeding up the process of professionalization of Sanitary Personnel by creating scientific literature concerning the theory and administrative practice of their work, by studying their educational and academic needs, by stimulating colleges and universities to inaugurate baccalaureate and postgraduate courses for their training, by encouraging the sanitary personnel to seek higher education, and by developing professional standards of qualifications and recommending that state government recognize their status legally.

The higher training of sanitation personnel is justified from all of society's past vocational and professional experience. A survey by the Engineering Section Project of the A. P. H. A. reaffirmed this principle when, based on data from 42 local health departments, it found that the highest ratings in sanitation and greatest efficiency of sanitation personnel existed in those health departments with the best trained sanitation personnel.

Qualifications of Public Health Sanitarians
(Adopted by the Governing Council of the A. P. H. A., Nov. 14, 1956)

Public Health Sanitarian Defined. A public health sanitarian is a person whose education and experience in the biological and sanitary sciences qualify him to engage in the promotion and protection of the public health. He applies technical knowledge to solve problems of a sanitary nature and develops methods and carries out procedures for the control of those factors of man's environment which affect his health, safety, and well-being.

Classifications. Five basic levels for the public health sanitarian are suggested:

Public Health Sanitarian I - This is the entrance or trainee level and permits recruitment of college or university graduates without prior experience.

Public Health Sanitarian II - This classification, in addition to requiring a college or university degree, requires one year of experience in public health or in work of a closely related nature. An employee of this class should be able to assume some professional responsibility for certain phases of environmental sanitation field work.

Public Health Sanitarian III - This may be considered principally as a specialty position in selected fields of work. To qualify for this class a person should be required to have three or more years experience in environmental sanitation, in addition to a college degree. This position may include certain supervisory responsibilities. Such position might include supervision and general direction of a section involving milk or food sanitation, housing, rodent and insect control, or general sanitation.

Public Health Sanitarian IV - This may be considered principally as a position at the supervisory and administrative level. At least four years of public health and sanitation experience should have been gained before assuming this position. A person in this class could be in charge of a bureau or division within a municipal, large county, or district department of health. The position would involve program planning, development, and evaluation along with certain administrative and supervisory duties. The promotional pattern would be to move from Sanitarian III to IV. Prior to assuming a position at this level, at least one year of the four-year experience requirement should have involved responsibility for the direction of certain other sanitation staff personnel. For this class a graduate degree in public health is

desirable and such degree may be considered the equivalent of one year of experience.

Public Health Sanitarian V - This classification may be considered as a position at the supervisory, advisory, or consultant level. It would be operative in large local health departments and within the structure of state departments of public health. The holder should have had six or more years' experience in environmental sanitation, at least two of which should have been in a responsible supervisory position. The minimum academic requirement would be a graduate degree in public health which may be considered the equivalent of one year of public health experience. The holder of the position should have broad general experience in environmental sanitation or should be a specialist in one or more phases of sanitary control. His work would involve the direction of personnel in a bureau or division, program planning, assistance to other members of the public health team, and the rendering of advisory assistance for both administrative guidance and program evaluation. Such position should be held by a person who has technical competence, has demonstrated ability to work effectively with others and has leadership qualities.

	Education	Minimum Health Experience	Public Health Courses	Title	Education	Minimum Public Health Experience	Public Health Courses
Public Health Sanitarian I	Bachelor's degree	None	Inservice and on-the-job training	Public Health Sanitarian IV	Master's degree in Public health	4 years	One year of graduate study leading to an M.P.H. degree (desirable)
Public Health* Sanitarian II	Bachelor's degree	1 year	Inservice and on-the-job training				
Public Health Sanitarian III	Bachelor's degree	3 years	Special seminars & inservice training	Public Health Sanitarian V	Master's degree in public health	6 years	One year of graduate study leading to an M.P.H. degree

*Graduates with a B.S. degree in sanitary science and public health, because of specialized preparation and field training, should start at the Sanitarian II level.

Desirable Personal Qualities

The personal qualities which are an asset to a sanitarian are that he be wholesome and self-confident, organizes his work productively, makes suggestions for improving operations, is interested in reasons for actions, does not participate in office gossip, has a sense of justice and fair play, constantly tries to learn more about the job, is able to say the right things at the right time and place, has intelligent curiosity, works well under pressure, keeps abreast of current events, displays warm and friendly feeling toward the less fortunate, cheerfully performs extra jobs, is always ready to help co-workers, is honest with his public contacts and fellow workers, accepts responsibility, is well-poised in usual situations, is a good listener, dresses appropriately for his work, is able to laugh at self, has a direct and realistic approach to any problem, can be firm, fair and dignified at the same time, has a good command of the English language, keeps his work up-to-date, learns and profits from experience, can adequately judge and report findings, easily establishes rapport, accepts instructions and is capable of teaching and giving instructions, is flexible in his thinking, finds satisfaction in a job well done, can intelligently question decisions of supervisors, is adaptable to new tasks and procedures, respects office hours, recognizes and admits his own mistakes.

Undergraduate Education of Professional Sanitarians

In 1948, the National Association of Sanitarians sent questionnaires to all its members inquiring about the educational needs of sanitarians. In the 1950-51 Year Book of the A.P.H.A., the Subcommittee on Training of the Engineering Section issued a report on undergraduate training of sanitarians. The April 1951 "Working Conference on Undergraduate Education in Sanitary Science" drafted a report on Training. In October 1951, the 3rd annual report of the above Subcommittee on undergraduate training was read at the A.P.H.A. meeting. All the data from these studies served as basic information for the development of the above statement of qualifications of sanitary workers. It appears from these studies that the undergraduate collegiate training of sanitarians should consist of, besides "elective" subjects, the following:

A. General Education during first 2 years should include at least:
   1. English and Speech - 9 semester credit hours.
   2. Mathematics including trigonometry, analytic geometry, integral and differential calculus - 6 semester credit hours.

3. Science
    a. Chemistry - general inorganic and qualitative - 8 semester credit hours.
    b. Physics - mechanics, sound, heat, light electricity - 6 semester credit hours.
    c. Biology - general zoology, and introductory bacteriology-6 semester credit hours.
4. Social Sciences and Humanities - psychology, economics, sociology, history and political science - 12 semester credit hours.

B. Concentration Program during junior-senior years.
1. Sanitary bacteriology - 4 semester credit hours.
2. Organic chemistry - 3 semester credit hours.
3. Medical entomology and parasitology - 3 semester credit hours.
4. Public health administration
5. Communicable disease control
6. Biometry
7. Health education

} 8-12 semester credit hours.

8. Environmental hygiene in relation to the basic sciences, physics, chemistry and biology - 10 semester credit hours.
9. Classroom and laboratory application of sanitary science in problem solving - 10 semester hours.

C. Field Training
Supervised field training of at least 12 weeks including orientation, observation, and active student participation in an operating program.

In 1962, recommendations of a group * meeting to reconsider the adequacy of sanitarian education were to a large extent in agreement with the 1951 recommendations of the Working Conference on Undergraduate Education in Sanitary Service. It recommended that specialization should be kept out of undergraduate education, and that a maximum of 12-16 semester hours be provided in sanitary science and public health to relate the basic sciences to the sanitary sciences and public health. Such education when supplemented by field training and appropriate length of experience is adequate for the sanitarian performing at the field level. The National Association of Sanitarians has established a National Accreditation Council to develop minimum standards for baccalaureate level courses and for accrediting the school curricula in the environmental sciences. In May, 1968, the Bureau of Health Services (PHS) initiated the development of an interne training program for sanitarians. The interneship is for 1 year.

At present, the following universities and colleges grant baccalaureate degrees designed for sanitarians: Univ. of California, Univ. of Denver, Univ. of Florida, Florida State Univ., Univ. of Georgia, Univ. of Indiana, Univ. of Massachusetts, Univ. of Michigan, Montana State Univ., Southern Illinois Univ., Univ. of N. Carolina, Ohio Univ. Univ. of Oklahoma, San Jose State College, Rutgers Univ., Tulane Univ., Utah State Agricultural College, Univ. of Washington, State College of Washington. Incomplete information on other Universities prevent their listing.

A broad cultural education provides the sanitarian opportunities for achievement, awakens in him an objective approach to problems, stimulates in him the further pursuit of knowledge, produces in him socially desirable attitudes and creative imagination, opens new horizons in sanitation to him, makes him more easily adjustable to particular job situations, and lifts such restrictions as might bind him to vocational specialization. Because the sanitarian's work keeps his attention centered on attaining uniform adherence to detailed laws, rules and regulations which do not change very often, he may develop a deep rooted emotional attitude of stability towards the status quo. A broad cultural training will tend to prevent him from becoming emotionally frozen to a particular practice and develop an outlook of acceptance of progressive change.

Graduate Education of Professional Sanitarians

A small but increasing number of sanitarians with a bachelor's degree seek further academic training at the graduate level. Most accredited schools of public health admit sanitarians with bachelor degrees to courses leading to master degrees. Some sanitarians go on to graduate de-

*A Report on the Disaster Capabilities of Sanitarians with Special Reference to the Academic Preparation of this Professional Group, Denver, Colorado, May 2-4, 1962.

grees in bacteriology, health education, medicine, veterinary medicine, engineering, hospital administration, research and other related fields. A sanitarian residency program in Community Health management has been set up by the Public Health Service to begin early in 1969 with headquarters at the PHS Hospital in New Orleans. It is a two year residency integrating graduate study at the University and preceptorship with the Louisiana State Health Department and the PHS Hospital.

Sanitarians wishing to devote their careers to supervisory positions in this field should seek one year of graduate work in public health to supplement their undergraduate training and their work experience. Obviously such graduated courses are best obtained in accredited schools of public health. Such schools are: Univ. of California School of Public Health, Columbia Univ. School of Public Health, Harvard Univ. School of Public Health, John Hopkins Univ. School of Hygiene and Public Health, Univ. of Michigan School of Public Health, Univ. of Minnesota School of Public Health, Univ. of N. Carolina School of Public Health, Univ. of Pittsburgh Graduate School of Public Health, Univ. of Toronto School of Hygiene, Tulane Univ. School of Public Health, Yale Univ. School of Medicine, Department of Public Health.

The Relationship of the Sanitarian to Other Health Workers

It has been accepted in most places in the United States that the director of a health department be a physician. Experience has made this choice. If we accept the thesis that the extension of knowledge and technology in the field of health and the changing conditions of society have made team-work a necessity where community health is concerned, we must then decide: "Who should be the overseer of community health programs?" The answer to this question should be based primarily on the criterion of competence to do the job best, although other criteria may also be valid, though not so compelling. Which of all health disciplines are subjected to the more rigorous and comprehensive education and training in the science of health and disease, and the art of healing, and the application of these to the needs of community life?

Among those whose disciplines are rooted in medical science, the physician is subjected to the most comprehensive education and training in the principles of health and disease. Among those whose disciplines are not rooted in medical science, there is no question of their lesser medical orientation as compared to physicians. Therefore, the physician, particularly the public health trained physician, with competence in administration and a flair for leadership is better qualified than an individual of another medical discipline with similar abilities to serve as the key administrator of a health agency, i.e., to serve as the integrator of the activities of the various health disciplines, the center, the core, the focal point on the health team. And, with the aid of such a team, the physician is most qualified:

1. To interpret and evaluate new knowledge for adaptation to community health programs.
2. To gain the trust of the people, and in fact, does have this trust, to render health services.
3. To decide when older theories and assumptions upon which practice is based should be changed, dropped, or modified.
4. To determine the priorities for which funds should be budgeted, and programs developed and stressed.
5. To evaluate the interrelation of activities performed by all the other medical disciplines.
6. To give over-all guidance to applied research in health agencies and set such research priorities.
7. To guide the educational needs of health agency staff.
8. To improvise for emergency situations.
9. To judge quality of health service.

The sanitarian has a definite job to perform. He has health laws, a sanitary code and administrative rules to follow, and a director to come to for consultation, aid, and moral support. He goes about his duty from day to day, performing routine services and keeping alert for signs and symptoms of the abnormal in the environment. It is important that the health officer be

available so that the sanitarian and other members of his staff may at all times counsel with him. The holding of frequent staff meetings is an effective way to maintain staff morale, to keep the staff informed of administrative problems and community health needs, to guide all efforts toward collective goals, and to keep professionally abreast by the interchange of knowledge.

It is imperative that the sanitarian confer with the health officer as regards to any of the following:

1. New program being developed or initiated.
2. Current program being changed, modified or discontinued.
3. Decisions or acts involving legal implications, such as a closure or seizure.
4. Statements of policy, procedure, or technical information to the press or at public gatherings.
5. Vacations or time off.
6. Leaving the area on official duty.
7. Accepting or desiring transfer to other health units.
8. Conferring or corresponding with health personnel of another political jurisdiction, concerning official matters.
9. Approving technical plans for constucting sanitary facilities which are more than routine in character.
10. Any other unusual occurrence or development.

Better than a relationship of boss to bossed between health officer and sanitarian is a relationship based on the principle of collaboration. In a health unit the degree of authority of the sanitarian, the nurse, and other personnel depends on the amount of authority delegated to each by the health officer. Where good relations exist, authority is understood and kept in the background while collaboration pervades and stands out. In health departments where there are several sanitarians, one of them is usually designated as senior or chief sanitarian. In this case the other sanitarians are guided in routine matters by the chief sanitarian who in turn is guided by the health officer. Thus the authority of the chief sanitarian is over-ruled only by the health officer.

The relationship between sanitarian and nurse should be that of collaborators in different aspects of the same work. They should realize that their work is closely tied together, and that one is incomplete without the other. A nurse who continues to visit a home that has poor sanitary facilities for excreta disposal or has an unsafe water supply, or where the family is suffering from hookworm disease or where diarrhea and other intestinal sicknesses are prevalent, and does not confer with the sanitarian about these conditions, is not performing an optimally efficient job. Conversely, the sanitarian, who, in his routine work, sees sickness and debility and does not confer with the nurse, is missing an opportunity to perform a good job. Similar collaboration should exist between the sanitarian and other types of staff members.

The sanitary engineers and sanitarians from the central and regional offices should be available for consultation on technical matters with the local sanitarian. The sanitarian should confer with state health department personnel with the knowledge of his health officer. A relationship of confidence should exist between the local and central personnel so that complications arising out of zeal in exercising authority may not develop. Where local health department exists, the state personnel should act as technical advisors whenever possible, whereas the local health director acts with administrative authority on local matters.

The sanitarian should be loyal to his work and his co-workers. But loyalty is not an end in itself. Loyalty is developed by such basic conditions of work and relationship as:

1. An interested, industrious, sincere, just, and understanding health officer.
2. A salary commensurate with one's responsibility, training, efforts and needs for adequate living standards.
3. Security in one's position when one is diligent, industrious, and adjusted to his surroundings.
4. An opportunity for self-development and promotion.

The Sanitarian and Politics

An encouraging fact of late is that the "political" sanitarian is beginning to disappear from the public health scene. The inefficiencies created by personally oriented political partisanship practiced within health organizations has been one of the symptoms of our political immaturity as a nation. Politics cannot be separated from social life. It is the instrument of social organization. But the level of political maturity of a people is expressed by:

1. Its recognition that politics is an instrument for social betterment, and not for individual aggrandisement;
2. Its practice of electing representatives to government whose interests are the welfare of the majority of the people;
3. Its demand that government administration create a mechanism for employment of government workers on the basis of merit rather than political patronage;
4. Its ability to accept the social changes which scientific progress and politico-economic forces thrust upon us.
5. Its recognition that people can actively help to direct their destiny, i.e., make their history within the limits of prevailing conditions.

To adhere to the precept that political skulduggery is a privilege of democracy is an admission that one has not grasped the elemental meaning of the concept of democracy. We could not hope to carry on an efficient program of sanitation if all of our positions depended wholly on political patronage. The activity of the sanitarian brings him into contact frequently with the leading people and governing bodies of the community and offers an opportunity to participate in partisan politics. It takes, at times, a considerable amount of courage to refrain from entering into such a political situation. Public health work should be based on science and its humane application, not on patronage of partisan politics. The public health worker must participate in politics to the extent of supporting the best possible program for the welfare of his people. The public health worker's political slogan might well be: "For the sake of social progress, not the party."

Unfortunately there is still entirely too much partisan politics and patronage plaguing the personnel of health departments in our country. The conscientious health worker often finds himself in a dilemma where this condition exists. The sanitarian who is not inclined to participate actively in the machinations of local political bosses can do best by keeping his mouth shut. The more vigorous sanitarian with a flair for leadership finds such a course frustrating and may not be able to contain himself. He may reason, and rightly so, that as a citizen who is interested in the well-being of his community, he deserves a voice in directing the course of his government. What such a sanitarian should do can not be put into a glib formula. Every sanitarian must realize, however, that not enough socially-minded, health-minded, far-sighted, intelligently informed people are today participating in the affairs of government.

There is an important place in politics for health workers who have made it their business to understand the difference between politics and political racketeering, between community needs and selfish group interests, and between progressive trends in government and the forces of regression. There is a great need for health workers with such understanding and with a gift of leadership to throw themselves headlong into the political arena to support the forces of progress. There is also a great need for health workers with political acumen to stay attached to their public health positions and to guide the health department through storms of political turmoil. The sanitarian should make a serious effort to analyze his capabilities and choose the course for which he sees himself fitted. If all health officers could be well rounded administrators with a feel for political movement, many problems could be solved for the other personnel of health departments. Civil service systems and merit systems are helping to cure some of the political headaches of public health workers.

The Sanitarian's Relationship to His Community

Now and then a health department receives a black eye because one of the personnel becomes careless about paying bills or gets a reputation for heavy drinking and carousing. It is of utmost importance for public health personnel to be in good standing with the community.

Debts should be paid promptly. Drinking should be done in private if at all. In other words, conduct should be exemplary in so far as possible, or at the least, not contrary to community morals.

The Sanitarian as a Teacher.

The sanitarian contacts many people in the course of his daily activities. His contacts are made under circumstances which can be utilized very frequently for spreading the health gospel. The efficient sanitarian never allows such an opportunity to pass. The education of the public is one of his basic functions. Every activity should be regarded as an educational opportunity. To be a teacher of sanitation, it is necessary to have a good grasp of the general functions of a public health program. These, considered in the modern sense, include the prevention of disease, prolongation of life and the promotion of physical and mental health and efficiency through organized community efforts directed toward the education of the individuals in the principles of personal and public hygiene, the sanitation of the whole environment, the control of all preventable diseases, the organization of medical and nursing service for the early diagnosis and preventive treatment of disease, the development of the social machinery which will insure to every individual a standard of living adequate for the maintenance of health, and the integration and organization of the above activities in such a fashion as will tend toward enabling every citizen to realize his birthright of health and longevity. *

The sanitarian must learn to utilize all methods of spreading the health gospel - give short talks in schools and to adult groups, help the health officer write articles on sanitation, set up health displays, lay out posters, distribute literature, show moving pictures, etc. Every sanitarian should know how to operate a moving picture machine. The sanitarian should know how to organize a program of education for food-handlers. One effective method is to organize classes for owners and managers of food handling establishments and for the food handlers themselves. At these classes a series of lectures and demonstrations are given on food sanitation. Restaurant sanitation could be greatly improved if permits for operating food handling establishments would not be issued until the owner or the manager has been given a copy of the regulations concerning food handling for study and has been declared proficient in the knowledge of food handling by the sanitarian after an interview-examination on the subject.

To be a good teacher, one must also be a good pupil. To be a good pupil, one must be a good listener and respect other peoples points of view although inwardly disagreeing. To be a good teacher in a community, the sanitarian must be respected and trusted by the people. This will depend upon his intelligence and knowledge, his initiative and industrious habits of working, his tact and good judgement, his integrity and enthusiasm for work, his pleasing appearance and ability to deal with people, his good health and good habits of personal hygiene. His ability to teach people should be so clever that his constituents should eventually appear to solve their own problems with what they think are their own ideas. The sanitarian learns not only from his books and journals, but also from his practices in the field. Many times techniques developed in the field by non-trained laymen have proved to be better than those categorically presented in text books. The eye of the sanitarian must be trained to evaluate and accommodate such techniques to his own uses.

The sanitarian must become an active member of the community in order to influence it effectively in the right direction. He must participate in its social life, belong to its organizations. He must be sympathetic to the lot and aims of the majority of people and support such aims as may bring social betterment to the people. Those organizations in the community which foster better living, adequate wages, more education, healthier environment should be supported by him, since these things are basically the fertile soil of better public health. Thus the sanitarian must distinguish between being a politician in the derogatory sense and being a participant in promoting social and economic betterment of the community. A sanitarian who becomes known as a friend of the people need not use the strong arm method of getting a job done; in fact, such a method is seldom necessary. He will be supported, if, now and then, it becomes neces-

*From the definition of Public Health by C. -E.A. Winslow.

sary to use police power to accomplish an important end over the objections of an obstreperous individual. The right psychological approach is important in getting an operator to use better up-to-date techniques. In approaching such a situation, it may be wise to explain to the operator that although his present practices may have had validity in the past, science has given us better methods which he would certainly want to adopt.

Public relations are the means by which a problem that effects the public's attitude is handled. It is, however, the mark of the master sanitarian to have the perspective to anticipate such problems and to handle them to the advantage of the people and the effective operation of the health department. Good public relations require that the sanitarian keep the public informed of his activities and prospective plans in order to gain its support. It also requires that the sanitarian know his problems well by frequent objective analysis in order to prepare his plans for public relations. The public must be made aware of sanitary requirements and be encouraged to call management's attention to questionable practices observed in public eating and drinking places. The need to resort to scare campaigns is an admission that other methods have failed. Although sanitary standards must never be relaxed, inspections never cease, research and education never stop, the sanitarian's work can be made easier by good public relations. The public just does not realize how exacting the sanitarian's job really is. This need not be so if he be backed by a favorable press and supported by a good educational and public relations program. A favorable press can be obtained by acquainting editors with the sanitarian's job and keeping the flow of news directed toward the press. There are few types of stories that are more interesting than the human interest stories which weave themselves into the activities of public health workers. The sanitarian must know the art of group contact, group planning, group work, and sharing responsibility. He carries his message to all organized and unorganized sections of the public, and, in turn, gets to feel the pulse of these by a system of advisory committees from each group. In this way common problems are discussed, mutual agreements reached and practical answers supplied. Thus, each group is awakened to its responsibility to the public health, and the sanitarian learns better how to accomplish his task.

Sociological Sciences as An Instrument for Understanding People

The public health worker must understand why people or groups of people live and act in certain patterns in order that he may help correct the fundamental factors causing anti-social acts and attitudes and foster those factors which produce social well-being. He must understand the dynamic essence of human nature, the potent influence of cultural patterns, the underlying social forces that determine social movement and the interrelationship of these in order to understand with some validity why social groups and individuals act as they do and how all this is important to the public health. The use of social epidemiology to develop effective means of rehabilitating neighborhood environments will be as successful as the sanitarian's knowledge of the sociological factors involved. The sociological dynamics of a community is as important to its health as the physiological dynamics is to the individual.

The Changing World and the Sanitarian

The theme of most widespread concern among people in general, and among every group of professionals, technicians, business men, and workers engaged in the multifarious pursuits of modern life is: "How to keep attuned to the rapid changes in the world today."

Can the sanitarian move forward in the stream of these swift changes, absorbing the new knowledge into the old and adapting this to the new conditions? To answer this in the affirmative, the sanitarian must demonstrate that he will readily apply himself to studying, mastering, and applying such newer fields of knowledge as the theories of atomic radiation and the simpler mathematical computations involved, the theories of sociological sciences and their implications in community planning for positive mental and physical health, the principles of the biological dynamics of bacteria, viruses, and fungi as these apply to food control, air conditioning, resistant microbic organisms, and epidemic communicable and degenerative diseases not yet controlled. He must further demonstrate whether he can cope with the problems involved in assessing the economic and aesthetic aspects of environmental control measures, in understanding and handling the threat and benefit of the endless volume of new chemicals being thrown into the

environment, and in deducing the priority needs of the community in order to pinpoint activities so as to utilize the limited sanitation manpower in the most effective manner.

Is the sanitarian the scientist that the situation demands? Is he secure enough in his educational background to be able to digest the lore of the past and the present and to use it as a guide to probe with confidence into the future? Problem solving is the test of competence. Let us examine for illustrative purposes some of the specific problems which the sanitarian needs to solve in order that he may satisfy himself that what he is doing is efficient in accomplishing a specific task, economical to the community in terms of cost and importance, and effective in controlling and promoting health.

1. In relation to the sanitizing of dishes: How much technological precision are we going to expect manufacturers of dish-washing machines to incorporate into their product without the cost becoming too prohibitive for the results obtained? Is bacterial control of dishes and utensils necessary with the same stringency regardless of how the implements are used, that is, is the same stringency in bacterial control necessary for dishes and utensils used for serving food as for preparation and storage of food? How important is the swab test for dishes and utensils in controlling disease spread? Does the work load on the sanitarian and the laboratory justify this practice?

2. How much mechanical implements and gadgets are we going to depend upon and require in food sanitation to overcome the simple lack or deficiency in hygienic practice by food handlers? Is food sanitation going to become the fertile field of exploitation for gadgeteering?

3. Is it possible to pinpoint our emphasis at certain strategic points in food process plants and in restaurants in order to control disease spread without depending upon greater elaboration of mechanization and cost?

4. What is the most economical and effective solution for the problem of sewage and other liquid waste disposal in suburban subdivisions and rural areas, particularly where terrain is low and flat and the water table high? What is the solution for solid waste disposal?

5. What aspects of housing are primary and which are secondary in affecting the health of people?

6. How many and which screening tests are important for the sanitarian to perform in the field in order to reduce the work load in the laboratory and to increase the effectiveness of his work?

7. What controls in the preparation and distribution of frozen foods need to be set up in order to reduce and prevent the hazards from this source?

8. How much more elaborate will sanitation inspection forms be allowed to become? Can better training of the sanitarian solve this problem and aid in the simplification of such forms?

9. Will the sanitarian prove his research ability by probing into the accumulated mass of regulatory provisions in sanitary codes, statutory laws, policies, procedures, and techniques in order to determine which of these are of secondary or tertiary importance, which are useless ceremony outmoded by newer knowledge, and which are critical areas of primary importance around which the main force of his work should be pinpointed? Can the growing mass of regulatory provisions be simplified?

The challenge to the sanitarians consist in whether they will be able:

1. To reexamine sanitary practices which had been formulated in the past from presumptive evidence or from lack of technological skill, and to bring a newer logic to the practice of environmental hygiene. This requires a renaissance in sanitary research by sanitarians in collaboration with public health engineers.

2. To develop knowledge and skills required for leadership in programs of city planning and urban and rural development.

3. To take leadership in solving the problems of waste (solid and liquid) disposal, including radioactive and chemical wastes disposed of into the air, into sewage, into water, and onto and into the ground, and in solving the problems of insufficiency of fresh water supplies, and the safety of animal and vegetable foods from radiation and chemical hazards.

4. To take leadership in safety programs such as relate to housing, neighborhood environment, highways, insecticidal and herbicidal practices, and other poisoning hazards.

5. To devise adequate means of sanitary handling of food, processed and distributed by newer developing techniques.

6. To take the lead in organizing the cooperative efforts of other agencies, in controlling such widespread disabilities as hay fever and asthma caused by pollenosis and other air pollutants, slums and sub-standard housing, and accidents, and in stimulating community leaders and whole communities of people to raise themselves out of slums and blighted neighborhoods.

7. To help develop the knowledge concerning the socio-environmental factors related to chronic disabilities and to devise procedures for control, as per example: What will the sanitarians' role be in the control of juvenile delinquency, crime, alcoholism, drug addiction, and the problems of aging?

Chapter III

PUBLIC HEALTH AND THE SANITARIAN'S WORK

To function at an optimum level, the sanitarian must be acquainted with the broad aspects of public health organization, function and administrative problems at the local, state and national levels and the various agencies involved in health work. Although public health practice has certain general similarities in every part of the United States, there are also many differences existing from place to place. Interstate laws pertaining to health are the same everywhere but each state has its own uniqueness in this respect, and each locality has developed its own character. Thus, there are now existing in our country over 20,000 sanitary codes. The reasons for the general similarities and unique differences are multiple. The sanitarian should become adept to analyzing the forces involved so that he may detect trends, and become aware of industrial, commercial, agricultural, financial, economic, political, social, climatic, and geographic problems that affect health status and practice. This will help him understand what aspects of standards, codes, statutes and public health practice may be better uniform or non-uniform.

Financing Health Departments

Throughout the history of public health in the United States, its beginning and subsequent development were stimulated mostly by emergency situations such as epidemics, floods and other natural catastrophies, wars, and economic depression. Emergency rather than deliberate consideration of the people's health has been the most prominent factor that prompted government expenditure of money for prevention and control of disease. There are indications that deliberate long-time planning of the people's health is coming to the fore.

In keeping with the dictum of Thomas Jefferson, the financing of programs for civilian health has been borne mostly by state governments. The funds for public health department activity, however, have been shared between state and local governments up to the time when rural health work began to develop. Since that time federal grants-in-aid have become important factors in financing official public health activity. In the last five years, for example, state and local appropriations averaged around 80% and federal around 20% of funds spent by official public health agencies. The amount of funds avilable for public health work is usually a reflection of the wealth of the state, the intelligence and the scope of understanding of this problem by state officials, the health consciousness of the population, and the vigor with which the national and local governments attack the problem.

In the United States, the lead in public health development came first from the urban seaport communities, next from the federal government and lastly from the states. The rapid growth of urban and industrial areas forced the states to take the lead in the latter part of the 19th century. In the meantime the disparity of wealth between the urban and rural areas grew rapidly, and the southern part of the United States with its large rural areas became one of the problem areas of the country. No modern country can develop properly if a large section of its population lives under backward, impoverished and decadent conditions. During the period of the first world war, the federal govenment began to re-assert its leadership by taking an interest in rural sanitation and in 1917 the first $25,000 became available to stimulate this work. The leadership in public health in the United States has swung from one level of government to another during our history, depending upon the various stages of development of our country.

The lead taken by the federal government in public health development has been interpreted from some very conservative quarters as a trend toward an unhealthful centralization of power and a decline in democratic local self government. Nothing can be further from the actual facts, since a vigorous democracy requires a vigorous prosecution of government activity, both at the central and local levels, each lending support to the other. There are, however, dangers inherent in too much centralization or decentralization.

The merits of federal participation in financing public health work have been (1) to stimulate county health organization, (2) to raise the standard of health practices among the states, (3) to stimulate states to raise their appropriations by requiring state matching funds, (4) to set up merit systems for public health personnel, (5) to encourage uniformity of policies, regulations, and laws in spheres of activity where this would be beneficial, (6) to redistribute tax money where it is most needed.

Local health departments such as county, district, township, and municipalities are usually financed by state and local funds. Some of the state funds may have an admixture of federal funds. Some municipalities may finance their own health departments entirely, but this becomes rarer as programs become more comprehensive. Voluntary organizations, help to finance local health programs for demonstration purposes. Actually, such funds play a very minor role in the total support of health work.

Practically all health departments lack adequate funds to carry on in accordance with the health needs of the particular locality. Thus the struggle for more funds takes up an inordinate amount of the health officer's time. The sanitarian can best contribute to this struggle by an exceptionally good job in sanitation and carrying on an active educational program, pointing out to the people what their sanitary needs are and the cost of projects to meet these needs.

Why this crisis in funds for public health? The most important reason is the irrational apportionment of government expenditures to the various government activities. One need only examine the budgets of governments of all levels and compare the annual outlay for public health to those for highways, police or military, rivers and harbors, etc. Such disproportions in expenditures are the result of disproportionate thinking by government which has grown out of partisan economic pressures.

Since the ability of state and local governments to provide adequate social services depends essentially upon their ability to raise revenues, and since the poorer areas of the country cannot furnish an adequate level of services from their own resources nor maintain their expenditures during depression periods, it is evident that federal aid and cooperation with state and local government to provide adequate social services are essential and necessary.

With our present financial and economic conditions, it is the federal government which has the freedom of action to collect revenues and make loans for the purpose of tiding the country over in critical times. The following table shows the federal government's increasing tendency to collect the greater share of taxes.

Table I

Percentage Distribution of Revenue Collections by Federal, State, and Local Governments 1902-1966

	1902	1919	1930	1945	1955	1966
Federal	19.0	57.4	32.7	81.6	71.0	64.7
State	13.9	8.5	19.9	8.6	14.3	18.3
Local	67.1	34.1	47.4	9.8	14.7	17.0

The ability of a locality to pay for services is usually based upon the assessed valuation of its real property.

In the distribution of funds from the Federal Government to States, or from State Governments to their local jurisdictions, a just measure must be found to determine local need and local ability to help itself. Whatever formula is developed to determine the shares to be received through such distribution, it should meet the following conditions:

1. It must contain a basic common denominator which will make possible a fairly good comparison of financial statuses of various local government areas.

2. It must provide adjustable factors when calculating data for local government areas in the poorest and richest categories. This is so, because the ability to contribute financially for social services changes in quality in these two extreme levels from what may be considered the average ability to contribute.

Rules of this type are used as guides only, but they can be very helpful if used wisely and with circumspection.

The Relationship of Federal, State, Local Health Authorities.

The inter-relationship of responsibility between the various levels of government in the United States is, generally, well defined except when the responsibility for the health of the people is considered. The welfare clause in the preamble of the constitution has been interpreted both for and against Federal government responsibility for the health of the people of the various states. Ultimately, it will not be a legal matter depending upon jurists' interpretation, but it will be a social necessity which will determine whether the states and local governments will be able to finance, organize, and administrate health work adequately, in the face of ever increasing demands, without Federal Government aid.

The powers granted to the Federal Government from which its authority over public health matters is derived, are:

1. Regulation of commerce among the States and with foreign nations.
2. Levying and collecting uniform taxes and spending.
3. Establishing post offices and operating a postal system.
4. Legislating for the District of Columbia and Territories.
5. Making treaties.
6. Assuming emergency powers during critical periods.

It is not difficult to realize how the above powers give the Federal Government certain devices for public health control. By controlling interstate and foreign commerce, trafficking of unwholesome foods and dangerous drugs and cosmetics, the spread of diseases between states and foreign countries can be controlled; by taxation, undesirable products may be discouraged from production and commerce; by postal control, shipment of undesirable products can be prevented; and so on.

The Federal Government has developed still another powerful form of influence over public health among the states - a more indirect means. This is accomplished by the granting of financial aid to State Governments. Such grants-in-aid are usually made on the basis of agreement between Federal and State Governments that the money must be used for specific purposes, and that certain standards of performance, organization, and administration be followed in the programs or projects so financed. It was by these means that states were encouraged to adopt merit systems for health workers thru out the United States. The changing functional relationship between central and local government is inevitable in the light of changing conditions, and it should be welcome so long as a democratic balance between the two is maintained.

There are a number of Federal agencies engaged in some form of health work. Most of the important ones have been transferred to the Department of Health, Education and Welfare. The following outline will give an idea of the character of the health work carried on by the Federal Government thru some of the more important agencies.

1. Agencies of the Department of Health, Education, and Welfare.
   a) The United States Public Health Service is authorized to:
      1) Control interstate and foreign quarantine,
      2) Control interstate distribution of biologicals,
      3) Supervise the water supplies of common carriers and railways and ship sanitation,
      4) Furnish medical and hospital service to merchant seamen, lepers, narcotic addicts, federal prisoners, and various officers and employees of the Federal Government,
      5) Maintain quarantine stations at airports used by planes from foreign points,
      6) Concern itself with stream pollution, shellfish sanitation, and various types of public health engineering projects,
      7) Cooperate with states in control of venereal disease, tuberculosis, typhus, malaria, cancer, and other diseases,
      8) Develop scientific research projects on public health matters,
      9) Collect and publish statistics and reports on public health subjects,
      10) Develop and facilitate public health training and education,
      11) Allocate social security funds and help States in the administration of these funds,

12) Cooperate with states, on request, in finding solution to most public health problems.

b) The Childrens' Bureau investigates and reports on infant mortality, maternal and child health, and general child welfare, and administers federal social security funds to stimulate programs for child and maternal health and welfare.

c) The Division of Vital Statistics collects, publishes, and distributes reports of births, deaths, marriages, infant mortality, and so on.

d) The Food and Drug Administration enforces the Federal Food, Drug, and Cosmetics Act, and other food control laws.

e) The Office of Education concerns itself with school hygiene.

2. Agencies of the Department of Agriculture.
   a) The Bureau of Animal Industry deals with the prevention, control and eradication of animal diseases and parasites, conducts research, administers the animal quarantine laws and the Federal Meat Inspection Act.
   b) The Bureau of Dairy Industry concerns itself with milk sanitation.
   c) The Bureau of Human Nutrition and Home Economics is concerned with foods and nutrition and home making.
   d) The Extension Service carries on health education activities.
   e) The Bureau of Entomology and Plant Quarantine studies and develops control measures for insects affecting man's health.
3. Agencies of the Department of the Interior.
   a) The National Park Service concerns itself with sanitation of national parks.
   b) The Bureau of Mines is concerned with safety and sanitation in mines.
   c) The Office of Indian Affairs supervises the health of non-citizen Indians.
4. Agencies of the Department of Labor.
   a) The Bureau of Labor Statistics studies reports on industrial hazards, accidents and working conditions.
   b) Division of Labor Standards develops and promotes standards of safety and health.
   c) The Women's Bureau formulates standards and policies for promoting the welfare of wage-earning women and improving their working conditions.
5. Agency of the Treasury Department.
   a) The Bureau of Narcotics enforces certain provisions of the Federal Narcotics Act.
6. The Post Office Department administers laws for the exclusion of dangerous and fraudulent articles from the United States mails.
7. The Veterans' Administration provides medical and hospital care to veterans.
8. The Federal Trade Commission administers the federal law pertaining to false advertising of foods, drugs, and cosmetics.

The above authorities and duties of the Federal Government are within the scope of the powers granted by the Federal Constitution. The State health authority is supreme in the particular state, and the various State Boards of Health are given the power by the particular state government to draw up sanitary codes which have the force of law, and to enforce the rules and regulations of such codes.

Local governments such as counties, townships, and municipalities have only those powers as are granted to them by the states. State Health authorities may intervene at any time in local health matters if there appears to be reason to believe that the latter are not efficiently executing the laws, but traditionally, this is usually not done without local request. A similar custom of courtesy exists between the Federal Government and the States in local matters that impinge upon Federal jurisdiction. County governing bodies have jurisdiction over health matters in the entire county outside of incorporated communities, but with the development of county health units, the local health jurisdiction of the smaller incorporated communities is more and more being consolidated in the county health unit by agreement between counties and municipalities.

Local health ordinances, regulations, and rules must not violate the minimum requirements of state laws and codes. The state laws and codes must not violate Federal jurisdiction. All legal matters of health departments are handled thru local, state, or Federal courts, depending upon the character of the case. Courts usually support health laws and activities which are reasonable in application. The word "reasonable" is an ambiguous term, but in practice, health departments have been supported by the courts in matters which are vital to the maintenance of public health. In many instances, not the courts but the laws are at fault in allowing continued violations.

Types of Positions Open to Well Trained Sanitarians

1. General sanitarians: in state and local health departments; in factories, milk plants, restaurants or restaurant chains or associations, public transportation companies; and in educational institutions.
2. Milk sanitarians: in the United Stated Public Health Service, state and local health departments, and in milk plants.
3. Food sanitarians: in U. S. Public Health Service, Federal Food and Drug Administration, state and local health departments, in factories, restaurants or restaurant chains or associations.
4. Field agents in insect and rodent control: in U. S. Public Health Service, federal and state departments of agriculture, and state departments of health.
5. Industrial hygiene sanitarians: with U. S. Public Health Service, state departments of health and various industries.
6. Training officers: U. S. Public Health, state departments of health and educational institutions.
7. Laboratory analysts: with U. S. Public Health Service, Federal Food and Drug Administration, federal and state department of agriculture, state and local health departments and milk plants.
8. Technical assistants: in stream pollution or industrial waste investigation for state departments of health.
9. Field agents in housing and other specialized activity: in local health departments.
10. Water and sewage plant operators: in local public works departments.

Public Health Survey

A public health survey is an analysis of the prevailing conditions, actual and potential, in an area, and the forces producing those conditions which exert or may exert a favorable or unfavorable influence on the health of the inhabitants. A sanitary survey is similar to a public health survey except that the emphasis is laid on the environmental conditions and forces involved, whereas the public health survey concerns itself equally with environmental as well as medical and sociological conditions and forces. The sanitary survey does, however, not entirely disregard the medical and sociological conditions and forces.

Surveys are valuable:

1) As a factor in stimulating active public interest in the conditions affecting the community health.
2) As an instrument in promoting public health education.
3) As the best means for determining objectively the status of health conditions in a community and the interrelation of the factors involved.
4) As a weapon for introducing health reform.
5) As a means of measuring the allocation of time and facilities to certain health programs.
6) As a measure of the facilities and natural resources.

An analysis of the conditions and forces which affect the health of a community must include the following:

A - Population

a. Composition:

Age, sex, race, nationality, urban-rural and occupational distribution, areas of density.

b. Social and Economic:

Principle occupations and industries, living conditions, traditions and customs, education, crops, economic status of urban and rural population, per capita income, per capita income by economic groups, taxable wealth, tax rate, total revenue, civic organizations and their activities, voluntary health agencies, official agencies engaged in health work, degree of distinction between social classes, per capita expended on public health, details of organization of school system, social security programs such as sickness, disability and old age insurance, and other protective programs.

c. Political, Legal and Governmental:
Governing machinery for the jurisdiction; elected and appointed officers; public health laws, regulations, and rules; effectiveness of law enforcement; political sub-divisions; length of tenure of office; special boards; boards of health, education, welfare and hospitals; appropriations for various purposes.

d. Growth:
Birthrates, character of population growth, and movement, trend in terms of quantity and quality.

B - Environmental Features

a. Geographical and Meteorological:
Size in square miles, section of state, distances to other important places, railroads and bus lines, mountains and hills, watershed, rivers, lakes, seacoast, swamps, high and low altitude, flooding, character of top-soil and sub-soil, water-table, amount of rainfall, mean temperature and temperture variation, humidity, barometer variations, winds, seasonal variation, flora and fauna.

b. Water Supply:
Sources and character of water, method of purification and distribution in urban areas, types and adequacy of rural supplies, potability, supervision and control by health authorities.

c. Waste Disposal:
Methods of disposal of excreta, industrial wastes, garbage, and rubbish.

d. Housing:
Types of building, public and private, state of repair, heating, lighting, ventilation, plumbing, number of buildings close to water and sewerage systems but not connected, screening, rat proofing, fire proofing, crowding, relation of housing to industrial hazards, nuisances and traffic hazards.

e. Food Supplies:
Sources; eating habits; effectiveness of inspection; methods of production, storage and protection; methods of distribution; training and supervision of food handlers; supervision of production with special reference to milk and milk products; meat and meat products; and seafood.

f. Arthropod and Disease Control in Animals:
Prevalence and potential factors prevalent for occurence of arthropod-bearing diseases and diseases of animals, control methods employed and their effectiveness.

g. Recreational Facilities:
Playgrounds, theatres, camps, gymnasiums, clubs, etc.

C - Morbidity and Mortality Data

a) Sickness and death rates of important diseases.
b) Case fatality rates for each disease.
c) Infant and maternal mortality rates.
d) Principle causes of death in area.
e) Distribution of deaths by age, race, economic level, occupational groups, etc.

D - Medical and Public Health Facilities and Personnel

a) Number of physicians, dentists, veterinarians, nurses, sanitary engineers, sanitarians, midwives, etc.
b) Number of hospitals, hospital beds: local and nearby, private and public; facilities for segregation and isolation; other facilites.
c) Clinics: public and private, capacity, facilities, distribution.

E - Outline of Local Public Health Program

F - Resume of Health Hazards Peculiar to Area, such as:

Unsewered areas of towns, rural areas of soil contamination by hookworm, anthrax, etc., mosquito breeding foci, rat-flea-typhus infected areas, low-grade industrial areas, industrial stream pollution, contaminated sea-food bearing water areas, unprotected milk and cattle areas, unsanitary dump areas, fire hazard places, poor housing areas, hazards peculiar to manufacturing processes (chemical, dust, mechanical) etc.

Project Planning, Costs, and Financing.

Because the sanitarian is concerned with the sanitary housing of food producing and dispensing establishments, he must become acquainted with techniques of construction, estimating

costs, and methods of financing. He must know the details of how to construct privies, septic tanks, wells, springs, cisterns, dairy buildings, slaughter houses, etc. He should be sufficiently acquainted with the larger forms of construction to work intelligently with the engineer.

A sanitarian should be able to make a survey of a county or city and estimate the facilities and work necessary to sanitate the area. He should know approximately how many of the needed facilities can be constructed considering the economy of the area, how much the material will cost per item, how well a particular project will be accepted in the community, how to interest the community in such a project, and how to finance such a project through a government agency. If the financing of a project is to be handled by the town or county, he should have a clear idea of how the financing is to be accomplished, whether by:

1. General Taxation - money taken from general funds which have been apportioned for the particular purpose.

2. Special Assessment - a tax levied against only that property benefited directly by the structure or service to be paid for. The amount to be paid by the individual property owner is proportioned, by law, in accordance with the benefit derived from the improvement.

3. Bond Issue - A governmental agency sells bonds and banks lend money because there is property in the area of political jurisdiction to secure the loan. The length of term of bonds should not exceed the estimated life of the equipment or improvement for which the debt is to be incurred. Short term bonds are issued for short-lived improvement. Short term obligations carry the lowest interest rates. A municipal bond is a promise by the municipality to pay the face value of the bond to the holder at a certain specified time, with interest at a stipulated rate during the interim.

a. General Obligation Bond - an issue of bonds for general improvement of the community. There is a statutory limit to the amount of bonds that may be issued by a local government. Bond issues must usually be presented to the voters for approval. The bonds are sold to a bonding house, or to private individuals, and funds are made immediately available for construction.

b. Revenue Bonds - differ from the general obligation bonds in that the security for the payment of principal and interest depends on payments to be made by users of the sanitary facility. This bond is not an obligation bond, and therefore it does not affect the amount of general obligation bonds that can be issued. Usually revenue bonds must receive approval of the voters of the district where the improvement is to be made.

4. Certificates of Indebtedness - are short-term-tax-anticipation warrants. These notes may be used when emergency funds are needed by the muncipality.

5. Governmental Grants and Loans - outright grants or loans by state or federal governments to local governments for improvement projects. Some states maintain a special fund for making loans to local governments.

6. Private Enterprises - a franchise may be granted to a privately organized enterprise to operate, usually under government regulations, to construct and operate a sanitary facility. The return on the investment may be obtained by a rental or service charge paid by the community or paid directly by the users of the facility.

The sanitarian should be acquainted with such techniques for repayment of debts as:

Sinking Fund - the treasurer is instructed to pay a certain amount every year into a fund which together with the accretion of interest will suffice to retire the whole bond issue at its date of maturity. This method is less commonly used today.

Serial Payment - the bonds are issued so that one or more matures in each successive year of the loan period. This method is more flexible and more commonly used today.

Pay-as-you-go - the public improvements are financed out of current taxes.

The sanitarian should know how to organize and operate a revolving fund. He should know how the initial fund is created from governmental, civic, or private sources or a combination of these, and how the fund is replenished from the payments made by those to whom the service is rendered. He should know how and on what basis the Federal Government helps to finance public health projects. He should know what his community can afford to spend, and consequently the feasibility of a particular type of project.

He should be acquainted with the steps in the procedure of the development of a sanitary project, such as:

1. The estimate of the cost should include:
    a. Labor
    b. Material
    c. Overhead, including such items as office expense, supervision, construction, plant, bond interest on borrowed money, insurance, transportation, etc. (This is usually 15 to 20% of the contract price.)
    d. Contingencies. (This is usually 10 to 15% of the contract price.)
    e. Profit. (This should be 5 to 10% of the sum of the 4 foregoing items.)
    f. Contract Price. (This is the sum of the preceding items.)
    g. Other items, such as
        (1) Engineering,
        (2) Legal Expense,
        (3) Purchase of land, rights of way, etc.
        (4) Extra work. This may range from 0 to 15% of the contract price.
2. A study of the particular sanitary needs with a preliminary report and estimate of cost.
3. A recommendation concerning the method of financing the project.
4. Publicity to secure public support and a favorable vote.
5. An engineering investigation preceding the final plan.
6. The plan, followed by the contract and the completion of construction.

If projects be developed through Federal Government aid, the sanitarian should know all the regulations related to such projects. From time to time the regulations of the various governmental agencies which are associated with community sanitation may change. The sanitarian must be alert to all such changes in order that he may secure the greatest advantage for the communities in his area.

Record Keeping and Program Planning

The sanitarian must never forget that he must keep records. Without records it is difficult to evaluate systematically the work that has been done, is being done, and should be done; how many sanitarians are required to carry on the work of an area under one or another set of conditions; why one area should accomplish more than another; etc. The sanitarian without records may have difficulty justifying his merits for advancement either in pay or position. Each state health department has its method of recording activity. The sanitarian must study and learn the significance of each record and suggest improvement of same if he sees fit to do so.

Record keeping is a job least liked by any field worker. Yet, if an appropriating body asks for a record of sanitary accomplishments over a certain period of time in order to consider whether it is justified in making appropriations for the health unit, the criterion for getting the funds will depend not so much on what has actually been done, but on how well records were kept on what has been done. A health officer cannot go empty handed to an appropriating body to get funds increased. Records count.

It does not pay to pad records. Such practices, sooner or later, react with embarrassing repercussions, since good supervisors can soon detect whether a sanitarian's records really reflect the work that has been done. The method of detecting such practices are based on the sanitary characteristics of the locality, the time element involved in making various types of inspections, the number of sanitarians in the area, and the actual sanitary progress in the area. Sometimes a problem occurs in relation to a particular item which requires the review of the past records concerning it. If the records do not reflect the real situation due to padding or to superficial inspection, the misrepresentation of the records quickly comes to light.

The sanitarian should plan his program. A monthly master plan of the next month's activities should be worked out. At first, the plan will not conform to the actual course of the month's work, but soon the sanitarian learns to evaluate the situation and to time his activities, and unless special problems arise during the course of the month, the actual activities will soon follow closely the setting of the plan. An organized plan of activity gives the sanitarian a feeling of smoothness and progress, it saves time and prevents confusion, and it creates a purposeful, deliberate approach that engenders confidence.

It is important that inspection sheets should be executed on the spot and not left to be filled out at a later time. Records of each inspection should be filed so that each establishment may have an easily available inspection history. Daily reports should be made out at the end of each day so that the important details of the days work may not be left unrecorded. A tickler file is an excellent adjunct to the sanitarian's planning procedure. It lends rapidity and efficiency and helps to establish regularity in planning. Correspondence should be taken care of promptly.

The Environmental Sanitation Program

The sanitary engineer and the sanitarian are the technicians and, to a large extent, the planners and executors of the environmental sanitation program. The public health physician serves as general advisor. The sanitarian concentrates on the administrative and inspectional aspects leaving the highly technical engineering aspects to the engineer. The sanitarian is the teacher, the public relations liaison, the supervisor, and the skilled field worker who carries on the inspection of facilities for sanitary maintenance and gives recommendations as to construction and reconstruction of less technical sanitary facilities. He gives guidance in hygienic practice relating to environmental factors. He inspects major technical facilities with the guidance and advice of the sanitary engineer. He may become the organizer, administrator, and planner of special or general sanitary programs on the state or local level. The good sanitarian quickly learns the extent of his technical abilities, and in what circumstances he requires the consultation of the engineer. These two categories of personnel are the inseparable team in environmental sanitation. Each has his definite place and both have a common meeting ground. Without considering the distinction between the two, the scope of activities of environmental sanitary personnel includes:

A - General
1) Reviews and approves plans for construction, remodeling, repairing or extension of all sanitary facilities.
2) Aids in the preparation and revision of and gives advice concerning codes, laws, ordinances, rules and regulations pertaining to sanitation.
3) Makes surveys of existing facilities and conditions and recommends improvements to local officials.
4) Makes special investigations upon request.

B - Water Supplies
1. Municipal
   a. Advises local superintendents on operations, laboratory procedure, etc.
   b. Checks operation efficiency of treatment plants.
   c. Collects specimens and interprets reports of analysis made by laboratory.
   d. Makes well location surveys.
   e. Reviews operation reports submitted by operators.
   f. Holds regional conferences for operators and superintendents.
2. Makes inspections and certifies to United States Public Health Service all drinking water used on common carriers.
3. Rural
   a. Devises plans for adequate well, spring, and cistern construction.
   b. Inspects existing facilities and recommends corrections where needed.
   c. Supervises building of new facilities or reconstructing old ones.
   d. Takes water samples where indicated.
   e. Organizes projects for obtaining adequate water supplies for rural schools and homes.

C - Excreta Disposal
1. Municipal
   a. Makes routine inspections of sewage treatment plants, and recommends improvements to local officials.
   b. Makes special field investigations to:
      (1) Check efficiency of plant.
      (2) Advise operator on plant operation and plant laboratory procedure.

2. Rural
    a. Organizes projects for obtaining adequate excreta disposal facilities for rural schools and homes.

D - Waste Disposal
1. Makes inspections and give advice to local officials and general population on garbage and refusal disposal.

E - Stream Pollution
1. Makes investigations of stream pollution including:
    a. Bacteriological and chemical examinations of stream water to determine extent of pollution.
    b. Determination of source of pollution, and chemical examination of sewage and industrial waste.
    c. Examination of the physical conditions of streams.
2. Prepares reports covering stream pollution investigation.
3. Assists in conduct of hearings on stream pollution problems or violations.

F - Swimming Pools
1. Makes inspections and advises managers and operators through reports and bulletins.
2. Interprets results of analyses.
3. Reviews weekly operation reports.

G - Ice Plants
1. Makes routine inspections of and gives recommendations concerning water supplies, cross connections, brine tanks, ice storage rooms, food storage, toilets, and other sanitary facilities.

H - State Institutions
1. Makes routine inspections of water supply, sewerage, garbage disposal, housing facilities, and milk sanitation, and reports findings.

I - Public Parks
1. Makes inspections of water supply, sewerage, garbage disposal and swimming beaches.

J - Communicable Diseases
1. Cooperates with epidemiologist by making the necessary sanitary investigation such as relating to water, milk, insects, rodents, and plumbing in the conduct of an epidemiological study.
2. Supervises emergency installations of water purification devices, etc. in case of epidemic or threat of epidemic.

K - Plumbing
1. Acts in advisory capacity to local enforcement agencies.
2. Makes plumbing inspections on all new or repaired installations.

L - Public Health Nuisances
Makes investigations on request, and advises as to corrections.

M - Summer and Other Camps
Makes inspections of sanitary facilities including water supply, sewerage, sewage disposal, refuse disposal, swimming pools, milk, housing and food handling and advises directors and operators on general sanitation matters and suggests improvements.

N - Milk Sanitation
1. Makes inspections and grades dairies or plants according to ordinances.
2. Serves as technical advisor for all milk sanitation problems.
3. Holds schools for instructing dairymen and milk plant operators.
4. Collects samples, sends them to laboratory and makes interpretations.
5. Prepares plans for dairy structures.
6. Helps to organize tuberculin and Bang's disease testing of cattle.
7. Develops pasteurization programs.
8. Inspects collecting and cooling stations.

O - Control of Insect Vector Diseases
1. Makes studies as to the character and extent of the problem.
2. Estimates cost of projects and recommends methods in line with local finances.
3. Organizes program for control.

4. Supervises the carrying out of the project, supplying the technical assistance necessary for drainage, spraying, screening or naturalistic methods of control.
5. Prepares plans and advises as to animal host control.
6. Collects samples of arthropods for identification.

P - Industrial Hygiene

1. Conducts preliminary survey of all types of industry to determine nature and magnitude of hazards caused by dusts, gasses, vapors, improper ventilation, poor lighting, etc.
2. Makes studies of hazardous processes and conditions, advising industries of findings and recommending methods of control, including atomic energy production and the use of radioactive materials in industry and science.
3. Reviews occupational disease reports and investigates cases reported.
4. Promotes the keeping of sickness records by industry and associated organizations and makes statistical analyses of such reports.
5. Acts in advisory capacity to enforcement agencies.
6. Conducts educational program to acquaint industry, labor and other interested groups with importance of program.

Q - Food Sanitation

1. Devises techniques for sanitary handling and preparing of foods.
2. Inspects all manufacturers, transporters, and vendors of food for:
   a. Adequate sanitary techniques and facilities,
   b. Health of food handlers,
   c. Registration of products and dispensation of permits for operation.
3. Cooperates in handling legal matters where violations have been committed.
4. Holds schools for food handlers, teaching them correct techniques and thus enlisting their cooperation through education.
5. Collects samples, sends them to laboratory and interprets the results.

R - Meat Sanitation

1. Examines all animals before slaughtering.
2. Examines all animals after slaughtering.
3. Draws up plans for sanitary slaughter houses and abbatoirs.
4. Devises sanitary techniques for handling meat.
5. Inspects regularly all slaughter houses and abbatoirs and techniques used.
6. Sees that meat-handlers are not disease spreaders.

S - Seafood Sanitation

1. Devises sanitary methods of transporting, packing and processing.
2. Sees that handlers are not disease spreaders.
3. Inspects all techniques and quality of seafood.
4. Inspects the physical condition of plants.
5. Inspects the waters from which sea food is taken.

T - Rabies Control

1. Cooperates in devising a plan and technique for controlling rabid dogs and preventing well ones from getting sick, mainly by:
   a. Vaccination and registration program.
   b. Dog-catching and impounding program.
   c. Quarantine measures when necessary.

U - Rodent Control

1. Surveys extent and nature of problem.
2. Determines the most effective and economical way of control.
3. Gives technical supervision in ratproofing, poisoning, and dusting.
4. Develops local projects.
5. Takes rat blood samples as a measure of the extent and progress of the work.
6. Collects samples of parasites for identification.

V - School Sanitation

1. Acts in advisory capacity to department of public education and other educational institutions on water supply, sewage disposal, heating, lighting, and ventilation.
2. Prepares and distributes bulletins and standard plans on sanitary facilities.
3. Makes routine inspections of schools.
4. Supervises school lunch room sanitation.

W - Housing, Lighting, Ventilation and Heating

Health Department jurisdiction in these matters usually extends to public buildings and places of business, but may serve in advisory capacity to federal housing projects or any private housing project upon request. Where State or local housing laws exist, direct action is taken in relation to private houses by making surveys, promoting slum clearance and rehabilitation of substandard houses.

X - Highway Safety and Other Accident Prevention

1. Cooperates with highway department in planning hazard elimination by consideration of:
   a. Width of road,
   b. Grade of incline and curve,
   c. Crossings,
   d. Closeness to schools, playgrounds, thickly populated areas, etc.,
   e. Control of speed,
   f. Competency of driver.
2. Cooperation in all accident prevention programs.

Y - Air Pollution

1. Participates in planning and operating an air surveillance program.
2. Collects air samples to determine pollution.
3. Makes inspection of places and practices that may possibly be responsible for polluting the air.
4. This area of activity could very well include programs for control of pollenosis.

Z - Research

Participates in all aspects of research pertaining to the environment as it impinges on the health of people.

Z^1 - Cooperative Work with Other State and Federal Agencies

1. Reviews plans and specifications of all sanitary projects financed with federal aid.
2. Makes inspections and acts in advisory capacity on matters of sanitation to state and federal agencies, including Farm Security Administration, Federal Housing Administration, Department of Social Welfare and Other government organizations.

Scope of Public Health Program

The scope of the entire public health program as it is generally practiced today includes the following: Communicable Disease Control in General, General and Special Medical Care Services, Hospital Administration, Tuberculosis Control, Venereal Disease Control, Maternity Hygiene, Infant and Preschool Hygiene, School Hygiene, Crippled Children Service, Adult Hygiene, Nutrition, Dental Hygiene, Cancer Control, Heart Disease and Chronic Diseases, Mental Hygiene, Industrial Hygiene, Laboratory Service, Sanitation, Civil Defense, Health Education, Statistics Compilation, Training of Personnel. Other aspects included are such activities as setting standards, making rules and regulations, developing sanitary codes, and promoting sanitary laws; prosecuting violations; supplying vaccines, toxoids, and other biologicals; consulting with physicians, community representatives, labor and farm groups, industry, and other organizations, official and voluntary; editing and publishing bulletins and pamphlets related to public health problems and conditions; carrying on research.

Program Development

In order to be able to work out a monthly program, the sanitarian should have crystallized in his mind the routine character of his work; and in order to be prepared for emergencies he should always have a grasp of the normal situation. The sanitarian's duties should be based on the following course of activities:

1) Inspections, follow-up of and recommendations for: Water supplies, excreta disposal facilities, dairies, milk cooling and collecting stations, pasteurization plants, frozen dessert plants, cafes, restaurants, bars, groceries, markets, taverns, lunch rooms, cocktail lounges, saloons, soda fountains, soft drink stands, bakeries, sandwich manufactories, coffee plants, abbatoirs and slaughter houses, syrup and sugar mills, ice

plants, bottling plants, rice mills, dehydration plants, sausage kitchens, commercial cold storage plants, freezer locker plants, fish ponds, other seafood handling facilities, public and parochial schools, hotels, jails, service stations, carnivals, bus stations, theaters, funeral homes, summer camps, migratory workers camps, tourist homes, tourist camps, trailer camps, convict camps, hospitals, institutions (blind, mental, orphanage, etc.), nursing homes, and perhaps other places subject to sanitary hazards and general nuisances.

2) Special program promotion involving supervisory and survey work in programs of: Single or small unit excreta disposal building, well installation, typhus control, mosquito and other insect vector control, rabies control, sanitation and safety control in disasters due to floods, storms, epidemics, bombings, and accident hazards, including radiation hazard control, and special concentrated efforts in other phases of sanitation.
3) Educational activities in: Food handling schools, milk handling schools, writing news articles, showing films, speaking to groups, routine contacts.
4) Collection and shipment of samples of: Water supplies, milk and dairy products, meat, seafood, other foods, drugs and cosmetics, streams, mosquito larvae and adults, rats, rat fleas, rat blood, and dog heads.
5) Special technical knowledge in supervision, maintenance, or construction of: Public water and sewage systems, sanitary pit-privies, septic tanks, dairy farm buildings, milk products plants, slaughter houses, wells, cisterns, springs, dish washing facilities, meat packing and producing plants, pasteurization plants, bottling plants, ice plants, cold storage, rat-proofing, drainage canals, garbage and refuse disposal, fly traps, screening, plumbing, swimming pools, and beaches.
6) Special technical knowledge and abilities to perform: Methylene blue test, orthotolidine test, milk sediment test, bromthymol blue test, strip cup test, percolation test, other simple food screening tests, testing adequacy of lighting. DDT dusting and spraying, preparing and setting out of rat poison, mosquito larvae destruction; calculations for making disinfectant solutions, milk standardization, swimming pool loads; motion picture machine operation; concrete mixing.
7) Routine administration in: Checking food handling and producing establishments for issuance of permits to operate; checking on food, drug and cosmetic producers for the registration of products; grading of dairies and milk distributors; checking on the certification and testing of cattle; executing the procedures to be taken against violators of the sanitary code, or other laws, ordinances, rules and regulations; evaluating the progress of general and special programs; planning to make every activity an educational opportunity; daily execution of activity report; prompt handling of correspondence; checking with nurses on matters of sanitation relating to observations in the field.
8) Other activities: Investigation of all reports of dog bites, investigation and follow-up of venereal disease cases, investigation and follow-up of other communicable diseases related to the sanitary program, keeping informed about disease prevalence and availability of sanitary facilities in case of emergencies, participating in professional and lay organizational activities.

Some Basic Guide-Lines

The Sanitarian must understand the general dynamics of disease occurrence and control to the extent that he becomes aware of the principles learned from experience, namely, that as one disease is controlled another one springs up to take its place, and that each method applied to the environment for the control of a particular disease may indeed become the instrument for aiding the propagation of another disease or another set of circumstances which contrives to perpetuate the risk in relation to the same disease.

The sanitarian must be aware not only of the short term cycles of disease occurrence, but also of the secular nature of epidemiological cycles. Thus, for different epochs of history, due to the changing conditions of living, as life and the environment evolve, various entities come to the fore to stamp their dramatic hallmarks on the times. The epidemiological hallmark of biblical, classical, and medieval times was leprosy: for the 14th to the 17th centuries, plague; for the period between the end of the 15th to the middle of the 16th century, syphilis; for the 17th and 18th centuries, smallpox and typhus; for the 18th and 19th centuries, tuberculosis and yellow fever; for the 19th century, cholera, typhoid fever, and other gestrointestional diseases; for the period between the middle of the 19th to the first quarter of the 20th century, childhood diseases; for the presently undetermined period beginning with the close of the second world war, viral infections, chronic diseases, psychosomatic conditions, and behavioral disorientation. These secular epidemiological cycles overlap, one into the next. In some instances, one cycle may be contained in the time span of another cycle. The beginning and termination of a cycle as designated above do not mean that the disease began and ended during that circumscribed span of time. The time span designates only that period during which the disease flourished in its most dramatic level of incidence.

Some of the more common environmental health problems of today were scarcely more than hypothetical considerations a generation ago, such as over-fortifying of foods with vitamins; disabilities resulting from excess cigarette smoking, automobile exhaust, and ionizing radiation; potential hazards from detergents; pollution of water supplies reaching dangerous limits of human tolerance; mass disabilities from allergies to various synthetic materials; alcoholism; congenital anomalies resulting from new drugs; hospital epidemics due to drug-resistant organisms; and occupational hazards resulting from sedentary and light-work.

The sanitarian of today and tomorrow must have the education to contribute to the solution of the problems for controlling the rapidly increasing hazards from radiation, from air pollution, from pesticide poisoning of the food supply, from home, highway, and industrial accidents, from water pollution and industrial wastes, from inadequate disposal of radiation waste materials, from environmental noise, from newer techniques of food production, and more.

The sanitarian must know how to plan for environmental health. Such planning must be based on fundamental knowledge of particular aspects of the subject and on the particular needs and desires of the community. The job, of course, cannot be done without adequate numbers of trained personnel. Where such personnel are not adequate, the sanitarian must be able to determine which activities have primary and secondary priorities. Considering the increasing urbanization, industrialization, and concentration of our population, the sanitarian must be fortified with a set of guide lines and standards that would lay the basis for his judgment in estimating what a community needs in comparison to what it has. This relates to financing, staffing, and salaries as well as environmental or ecological factors that determine the level of community health. The sanitarian must, therefore, have information of the sociological patterns of the community which influence its health. It is, of course, basic that all areas should be served by a local health department.

Guide-Lines for Control of Basic Aspects of the Environment*

Concerning the environmental aspects, the following should be used as guide lines for the basic environmental areas, such as, water supplies, sewage disposal, refuse disposal, air pollution, housing:

*Environmental Health: Planning Guide, U.S. Public Health Service Publication No. 823, also issue of September 1967.

1. Regulations should be in effect which establish minimum construction standards for private water supplies.
2. Regulations or ordinances controlling refuse collection and disposal should be in force throughout the area.
3. Standards for the storage and removal of refuse from individual premises should be in effect.
4. Enclosed trucks should be required to prevent nuisance conditions caused by blowing and scattering of truck contents.
5. The use of open dumps should be prohibited by regulation.
6. There should be a definite policy regarding the use of interim sewage treatment plants. These plants are sometimes used to provide service during transitional periods before an area's population density warrants connection to central treatment facility.
7. a. A local enforcement agency should be responsible for regulating on-lot sewage disposal. b. Soil percolation tests are recommended as a means of evaluating the ability of the soil to absorb the wastes. c. The use of accurate soil maps is suggested to evaluate soil conditions as an adjunct to the more precise percolation tests. d. A deep soil test is needed to determine subsurface characteristics, and such a test should be part of the local regulations. e. An indication of the septic tank failure rate may be obtained by determining the number of septic tank complaints per year as compared to the total number of septic tank installations.
8. Any growing community should be actively engaged in planning for future land use, including the preparation of a master plan.
9. Public sewerage service areas should be based on population density and topography.
10. Public sewerage jurisdictional areas should be related to drainage areas and should reflect anticipated growth patterns.
11. A sewerage master plan showing future needs and facilities is necessary in attacking the problem of urban growth.
12. A sewerage system which allows flexibility to meet changing conditions is desirable.
13. When public facilities are available, connection to such a system should be required, since this allows better system planning.
14. The community should have a definite policy for determining the method by which sewer line service extensions are made.
15. The community should provide treatment for all sewage.
16. A determination of total sewerage service is useful to compare local system costs with each other and with costs in adjacent areas.
17. Areas can be evaluated by the following table to determine whether there is justification for installing public sewerage services:

Population Density	Equivalent Lot Size	Service Economic Justification
Over 5,000 persons/sq. mi.	Less than 1/2 acre	Public sewerage is justified
2,500-5,000 " " "	1/2 to 1 acre	Public sewerage is normally justified
1,000-2,500 " " "	1 to 2 acres	Public sewerage is not normally justified
Less than 1,000 persons/sq. mi.	Over 2 acres	Public sewerage is rarely justified

18. A small number of community water utilities is preferable to a multiplicity of uncoordinated systems.

19. A master plan which shows future water needs and facilities in relation to the area's growth and water resources is necessary for effective planning.

20. Regulations calling for mandatory connection to public water supplies, where public water service is, or could be made available, are recommended for allowing better system planning and financing.
21. The community should have a definite policy for determining the method by which water service extensions are made.
22. The treated water should meet State and U. S. Public Health Service quality standards, including schedule for testing.
23. Capacity and storage should be such as to provide quantities of water adequate for maximum day demands, without significant loss of pressure.
24. Although no empirical figure can be provided as a "reasonable" water rate, the cost of water should be fairly consistent throughout the area and should be reasonable enough to encourage connection to the public supply.
25. Public water supply should be provided where service is justified, using the following guide:

Population Density	Equivalent Lot Size	Service Economic Justification
Over 2,500 persons/sq. mi.	Less than 1 acre	Public water supply is justified
1,000-2,500 " " "	1 to 2 acres	Public water supply is normally justified
500-1,000 " " "	2 to 4 acres	Public water supply is not normally justified
Less than 500 " " "	Over 4 acres	Public water supply is rarely justified

26. A governmentally regulated system of refuse collection is preferable to the practice of having individual competitive haulers deal directly with the homeowner.
27. A master plan based on a thorough engineering analysis for the collection and disposal of refuse is vital in rapidly growing communities.
28. Of prime economic importance is the proper location of disposal facilities in relation to future population concentrations.
29. A definite policy should be established for extending refuse collection service areas, including the determination of frequency of collection.
30. Refuse collection should include both rubbish and garbage.
31. Refuse service charges throughout the area should be determined.
32. Because of nuisance conditions and health hazards, open dumps are not acceptable.
33. Operating costs for sanitary landfills currently (1960) range from $1.00 to $1.50 per ton of refuse. Incinerator costs are considerably higher, but may be offset by shorter haul distances. Cost of incineration usually ranges from $2.00 to $5.00 per ton of refuse.
34. Public collection and disposal of refuse should be provided where service is justified, using the following guide:

Population Density	Equivalent Lot Size	Service Economic Justification
Over 2,500 persons/sq. mi.	Less than 1 acre	Service is justified
1,000-2,500 " " "	1 to 2 acres	Service is normally justified
500-1,000 " " "	2 to 4 acres	Service is not normally justified
Less than 500 " " "	Over 4 acres	Service is rarely justified

35. Air pollution control regulations should be established if atmospheric contaminants result in significant deleterious effect in the community.
36. In addition to the investigation of air pollution complaints, many communities use a permit system in their control program. This provides a technique under which prior approval is given only if the controls to be provided are adequate to meet requirements on the emission of air pollutants.
37. Air pollution monitoring programs are useful both in determining the extent of the problem and also in measuring progress.
38. Development of a sound, long-range program of prevention and/or correction of air pollution is greatly aided by good zoning regulations.
39. The following chart can be used for information as to types of air pollutants, effects resulting from each type, usual sources of these pollutants, the primary causes, points of emission in the atmosphere, suggested methods of control, recommended enforcement measures and the physical characteristics of the contaminant.
40. The only way to prevent slums is to insure that all of the area has a comprehensive set of regulations and programs for the control of both new and existing dwellings.
41. Housing programs should utilize a systematic evaluation of housing and neighborhood quality. The APHA Housing Quality Appraisal Technique is perhaps the most widely accepted method, but locally developed methods have been used.
42. Many communities are finding that urban renewal projects are worthwhile for certain deteriorated areas. Before entering upon an urban renewal program, evaluation of housing conditions is needed.
43. Consideration should be given:
    a. For improved coordination between departments (such as health and planning).
    b. For creation of new divisions in the health agency to be responsible for new or unfilled program needs, such as, pollenosis control, accident control, food production and distribution.
    c. For ordinances or regulations relating to various health and public works services.
    d. For creation of various types of sanitary district authorities.
    e. For extensions for water and sewer services into new areas.
    f. For new or improved subdivision regulations.
    g. For State enabling legislation needs.
    h. For better coordination or consolidation of city and county health activities.
    i. For detailed long-range facility planning.
    j. For detailed engineering or economic studies of special community services.
    k. For appointment of new commissions or committees to handle special problems.
44. There should be cooperation of physicians in reporting cases of food-borne diseases in order to maintain effective epidemiological investigation to determine the source and causative organisms.
45. There should be frequent review and evaluation of program needs, objectives, and achievements in food control.
46. There should be laws and government policy for federal, state, and local government health agency cooperation in food control programs to identify and evaluate human exposure and sources responsible for food-borne diseases, and to develop effective control measures.
47. Standards for health protection should be adopted and enforced relating to medical, dental, industrial, and research sources of radiation.
48. The preparation, handling, distribution, uses, and transportation of naturally occurring and artificially produced radionuclides should be thoroughly controlled.
49. Standards of operating nuclear reactors must be included in control programs.
50. An effective routine monitoring program should be established as one part of community radiological health activities. A monitoring and laboratory competence far greater than is needed for "routine" surveillance must also be available when counter measures need to be taken to control dangerous levels and population exposure to radiation.
51. There should be an on-going training program established to maintain an adequate and competent corps of personnel for radiation control activities.

52. There should be a program for measuring the ambient air pollutant concentrations, the effects of these on the community, and the magnitude of emissions from known sources; for maintaining a complaints record system; and for carrying on a continuous evaluation of the air pollution problem.
53. There should be laws, ordinances, rules, and regulations for control of air pollution and the evaluation of control programs.
54. There should be an air pollution advisory committee consisting of 5 to 10 active, interested members who can be effective in developing community support for an effective control program.
55. Prevention should be the keynote of air pollution control which should include planning and zoning, active personal contact with major or pollution source operators, intimate knowledge of air pollution sources, and a permit and registration system.
56. There should be adequate laws, ordinances, rules and regulations for comprehensive coverage for protection of all potentially hazardous food produced, processed and sold in the community, and the administration of these laws should not be fragmented among several agencies.
57. The public should be kept informed and aware of proper food protection practices.
58. Public health laboratory facilities should be available for surveillance of potentially hazardous foods and for the investigation of suspected food-borne disease outbreaks.
59. There should be cooperation of industry and government, and of different levels of government to assure an effective food protection program.
60. There is need for the enforcement of high standards of public health in recreation, and a modus operandi must be developed and implemented for the cooperation of all levels of government and private enterprise for planning, provision, and maintenance of sanitary facilities in the recreation environment.
61. Among the requisites for a safe and healthful recreation environment are: (a) Site selection, (b) water shed management, (c) water supply, (d) sewage disposal, (e) plumbing, (f) building and housing hygiene, (g) food service sanitation, (h) refuse handling, (i) swimming pool and outdoor bathing places, (j) travel-trailer parking, (k) boating, (l) fish-cleaning facilities, (m) insect and rodent control, (n) recreation safety, (o) camp grounds and picnic areas, (p) stable sanitation for horses.
62. Because of the special problems peculiar to recreation areas such as seasonal operation, public behavior, vector and animal problems, remote locations, and landscape and wild life protection, there should be an on-going active research program in operation to help the problems related to:
    a. Adequate design criteria to plan recreation areas more effectively for the purpose of preventing public health problems;
    b. Adequate control measures for disposal of sewage and wastes from pleasure boats, house boats, and homes on or along lakes and bodies of water, etc.
    c. Design criteria for water supply, sewage treatment, refuse handling, and other sanitary facilities for various types of recreational facilities;
    d. Organizational and administrative methods for solving the problems created by the public's behavior in relation to recreation areas.
    e. According to the National Recreation and Park Association, the nationally recognized and generally accepted standard for recreation space located within municipal limits is 10 acres per 1,000 of the ultimate population as outlined below:

	Acres/1,000 ultimate population
Near at Hand:	
Neighborhood Recreation Areas	2.5
District Recreation Areas	2.5
Within an hour's travel:	
Areas within municipal limits	5.0
Total	10.0

There appears to be some agreement that there should be at least 15 acres of regional recreation area per 1,000 of the metropolitan population, located within an hour's travel of the municipality.

63. To insure against slum development, a comprehensive set of laws, regulations, and programs to control both new and existing dwellings is needed.
64. Housing programs should utilize a systematic evaluation of housing and neighborhood quality.
65. Neighborhood organizations, such as Home Associations, dedicated to improvement of housing maintenance and occupancy conditions are needed, and these should be fostered and coordinated by some official agency or committee.
66. In all measures taken to attain quality residential environment, programs against home accidents should be a part.
67. Where needed, urban renewal projects should be considered for deterioriated areas.
68. Although all communities may not need "every" type of sanitation service, where necessary, services for the following should be established: (a) Child care homes, (b) general sanitation complaints, (c) hospitals, (d) hotels and motels, (e) industrial hygiene, (f) accident prevention, (g) noise control, (h) nursing homes, (i) pedestrian circulation safety, (j) plumbing inspection, (k) schools, (l) swimming pools and bathing places.
69. Solid waste collection should be a regulatory function of government. The collection system should be either directly operated by government or privately operated under government supervision.
70. A master plan, based on thorough engineering analysis, for collection and disposal of solid wastes is vital in rapidly growing areas.
71. Of prime economic importance is the proper location of disposal facilities in relation to future population concentrations.
72. There must be close coordination between the solid waste collections and disposal services, the planning of community transportation, and the planning for future recreational areas.
73. Definite policy should be established for extending service areas.
74. Collection of residential refuse should include both rubbish and garbage.
75. Household incineration of combustible refuse should be carefully regulated to prevent unsanitary conditions resulting and to control air pollution.
76. Solid wastes collection service charges should be specifically determined for the area.
77. Because of nuisance conditions and health hazards, open dumps and open burning should not be accepted.
78. The disposal site should be as near as possible to the area served, preferably not more than 10 miles away.
79. Vector control should be part of the health department's program for controlling communicable diseases and nuisance.
80. To be effective, the vector control program must cover the entire problem area.
81. Continuous effort is necessary to limit and control areas where vectors can harbor, feed, and breed, and periodic survey of vector populations should be conducted.
82. A continuous education program must be carried out to keep citizens apprised of their responsibility in eliminating sources of vector feeding.
83. Commercial pest control operators should meet standard requirements of training, experience, competence, and performance to qualify for a license.
84. There should be a State comprehensive health planning agency and area-wide comprehensive health planning agencies under which comprehensive environmental health planning activities are part of the whole system of comprehensive planning.

Sanitarians' Equipment

The following is a list of equipment which sanitarians might use in their work. Not all items will be required, as their use will depend on the programs being carried out. The list is in no way complete. The categories covered are general environmental sanitation, food control, milk control, insect and rodent control, swimming pools and individual water supply and sewage disposal installations, but not industrial hygiene, stream pollution, sanitation laboratory supplies, and insecticidal vector control. (U.S.P.H.S. 1959)

Item	Areas of Use
Thermometer 0^{o} to 220^{o} F(max.reg.) in metal case	All
Thermometer, -30^{o} to 120^{o} F, in metal case	All
Bayonet type Thermometer, 30^{o}F to 220^{o}F	All
Thermometer, max.reg., with case, 138^{o} to 148^{o}F	MP
Thermometer with case, 138^{o}F to 171^{o}F	MP
Chlorine Litmus Paper, in case	MP,MF,F,FP
Color Comparator, Hellige (or equal)	SP,W,S,MP,MF,FP
Color Disc Chlorine 0 to 1 PPM	SP,S,W,MP,MF,PP
Color Disc pH 5.2 to 6.8	SP,S,W,MP,MF,FP
Color Disc pH 6.8 to 8.4	SP,S,W,MP,MF,FP
Color Disc pH 8.0 to 9.6	SP,S,W,MP,MF,FP
Klenzade(or equal)Chlorine Test Kit, Range of 12 ppm increments	All
ABCB Caustic Test Kit	FP,MP
ABCB Alkalinity Test Kit	FP,MP
Holding Time Testing Kit,HTST	MP
Pressure vacuum testing kit 30" Hq. to 200 p. s. i.	ALL
Scherer Rapid Phosphatase Field Test Kit	MP,F,MP
Blak-light(or equal)U-Violet Light Portable Inspection Kit	RAT,MF,MP. FP,F
Q.A. Litmus Paper, in case	MP,MF,F,FP
Elliker Test Kit (Q.A.)	F,MP,MF,FP
Swab-rinse Test Kit	MF,MP,F,FP
Combination Air Velocity and Static Pressure Test Kit	F,SC
LaMotte(or equal)Food Test Kit	F
Millipore(or equal)Sanitarian's Field Membrane Filter Test Kit	F,MP,MF,FP,W,S
CDC Training Branch(or equal)Water and Sewage Field Test Kit, Excluding Chlorine and ph Test Equipment	W,S,SP,MP,MF
Post Hole Auger	S
Collapsing Metal Tape,50'	All
Light Meter, 0 to 100'/ candles	All
Disc Type Water Meter	All
Cylinder Torch, Gas	W,SP
Carpenter's Level	MP,S
Sling Psychrometer	SC,F,MP,FP
Water Visibility Disc and Cord	SP
LEAD SEAL PRESS	MP
(p/100) Lead Seals	MP
Milk Stirring Rod	MF,MP
Aluminum Milk Thiefs, Approximately 3/8" dia.	MF,MP
Steel Rat Traps, #0	RAT
Pill Boxes	IC,RAT
Collection vials with 70% alcohol	IC,RAT
Fly Survey Grill	IC
Fly Trap	IC
Grain Sampler	IC
Double can for Dog Heads	R
Mosquito Larvae Dipper or Pan with Pipette	IC
Pocket Magnifying Glass, 5 x to 20 x	IC,RAT
Chloroform Tube	IC
Folding Metal Clip Board	All
Slide Viewer, 2" x 2"	All
Insulated Sample Box Approximate 3 cu.ft.	All
Single Clip Brief Case,large	All

Chapter IV

Fundamentals of Microbiology

No science is more fundamental to the understanding of sanitation than microbiology. The sanitarian who knows why he practices certain techniques in controlling the environment against communicable disease hazards knows also the fundamentals of microbiology. The more he knows of this science the better a sanitarian he may become because this knowledge gives him an instrument for improvising in the most diverse circumstances.

Because cellular microorganisms are living entities, they grow, develop, reproduce, breathe, take in food, give off waste, respond to stimuli, and require particular conditions in order that these essential processes may continue. Living matter requires a particular external environment with which to react in order to maintain its vital nature, i.e., its living state. Different types of living things require different types of external environment to satisfy their constitution and their internal vital processes. That particular nature of living matter which determines the environmental conditions in which it is able to grow, develop and reproduce is hereditary. If the conditions which the heredity of an organism requires be not available, the organism will die, unless the nature of the organism becomes modified so that it may continue its existence in the new environment.

Ordinarily, we think of unicellular organisms as sexless, because in most instances they reproduce by dividing in two or by developing buds which break off from the mother cell. There appears to be no union of opposite sex elements in their process of reproduction. But this is only apparent because each cell seems to contain within itself both sex forces which are in a continual process of uniting and in a continual process of reproduction. This explains why one-cell organisms reproduce so rapidly. There is also evidence that some single cell organisms go through phases of sexual union in the process of reproduction.

Before microorganisms were discovered and studied, it was believed that all living things were either plant or animal. Transitional types were not thought to exist. During the nineteenth century, however, it became clear that the microorganisms combine both plant and animal properties in all possible combinations. We believe, today, that they have evolved, with relatively little change, from the common ancestors of plants and animals.

To categorize all organisms in either of the two "kingdoms," plant or animal, has resulted in some irrationalities. In order to avoid the arbitrary assignment of transitional groups to one or the other kingdom, Haeckel, in 1866, proposed that microorganisms be placed in a separate kingdom from either plants or animals. He called this kingdom Protista. Members of the kingdom, Protista, are distinguished from true plants and animals by their simple organization. They are unicellular, or, if multicellular, they do not develop differentiated tissues. On the basis of this classification, Stanier et al* proposed the following classification of the Protista:**

I. Higher protists: Cell structure similar to that of plants and animals.

Algae (except blue-green); Protozoa; Fungi; Slime molds.

II. Lower protists: Cell structure greatly simplified.

Bacteria; Blue-green algae.

* The classification proposed by Stanier, Doudoroff, and Adelberg in The Microbial World, 2nd ed., Prentice-Hall, 1963.
**Medical Microbiology, E. Jawetz, J.L. Melnick, E.A. Adelberg.

The bacteria include the organisms called rickettsiae which differ from other bacteria only in being somewhat smaller (0.2-0.5μ in diameter) and in being obligate intracellular parasites. They were formerly thought to represent a transitional group between the bacteria and the viruses.

The rickettsiae are rodlike, ovoid, or spherical in shape, and are much smaller than bacteria. Like the viruses they multiply in living tissues only. They are, in size, intermediate between the large viruses and the bacteria. They are believed to multiply by fission, and their mode of nutrition and multiplication is not fully understood.

Some members of the rickettsiae have been shown to have a definite metabolic activity. They are susceptible to antibiotics; in this respect they resemble the larger viruses, the small viruses being resistant to antibiotics. Rickettsiae are primarily parasites of insects, and some are pathogenic to their insect hosts. Many of them are pathogenic to man, to whom they are transmitted by the bite of the insects carrying the rickettsiae.

It is now clear, however, that viruses are sharply differentiated from all cellular organisms, including rickettsiae and other bacteria and do not belong to the protista. A viral particle consists of a nucleic acid molecule enclosed in a protein coat.

Higher Protists. The higher protists share with true plants and animals the type of cell construction called eucaryotic ("possessing a true nucleus"). In such cells, the nucleus contains a set of chromosomes which replicate by mitosis.* The cytoplasm of the cell contains mitochrondria and vacuoles, and the cell membrane is continuous with the inner cell structure and nuclear membrane. Motility organelles (cilia or flagella) are complex multi-stranded elements. In contrast, the lower protists exhibit a much simpler cell construction, called procaryotic.

1. Algae: The term "algae" refers in general to chlorophyll-containing higher protists. There are four general properties which are constant enough within related series of algae to be used as a basis for classification: they store starch as food reserve; they have photosynthetic and other pigments as found in true plants; they form reproductive elements, i.e., gametes, in unicellular sex organs; the motile cells have 2 or 4 anterior flagella of equal length.

2. Protozoa: Several types of photosynthetic, flagellated, unicellular algae-like forms should be included among the protozoa. These include members of Volvocales in Chlorophyta, members of Euglenophyta, the dinoflagellates in Pyrrophyta, and some of the golden-browns in Chrysophyta. They may be classified as algae but because of their phylogenetic or evolutionary position, they should be recognized as a link to typical algal forms. These photosynthetic flagellates could therefore probably represent transitional forms between algae and protozoa. According to this view, the protozoa have evolved from various algae by loss of chlorophyll.

The most primitive protozoa are, therefore, the flagellated forms. "Protozoa" are unicellular, nonphotosynthetic higher protists. From the flagellated primitive protozoa, the ameboid and the ciliated types appear to have evolved. Among the protozoa are the dysentery causing amoeba, the trypanosomes of African sleeping sickness, the plasmodia of malaria, and the harmless paramecia.

3. Fungi: Although some characteristics of the fungi appear similar to those of the algae, it appears, however, more reasonable to trace their origin from the protozoa.

The fungi are nonphotosynthetic microorganisms growing as a mass of branching, interlacing tubular filaments ("hyphae") known as a mycelium. The cross-walls in the hyphae are

*Mitosis is a method of indirect division of a cell, consisting of a complex of various processes, by means of which the two daughter nuclei normally receive identical complements of the number of chromosomes characteristic of the body cells of the species.

perforated and allow the free passage of nuclei and cytoplasm. The mycelial forms are called molds; a few types, yeasts, do not form a mycelium but are easily recognized as fungi by the nature of their sexual reproductive processes and by the presence of transitional forms. The fungi differ from bacteria, including the filamentous actinomycetes, in being eucaryotic. The fungi include the Phycomycetae to which the pathogens, Coccidioides, belong; Ascomycetae to which the yeasts, Penicillium and Aspergillus, belong; Basidiomycetae to which the common mushroom, Agaricus campestris, belongs; and the Fungi imperfecti to which belong the pathogens, Dermatophytes (Trichophyton, Epidermophyton, and Microsporum), Blastomyces, Histoplasma, Sporotrichum, Cryptococcus (a yeasts-like fungus), Candida (a yeasts-like fungus).

Although the fungi are classified on the basis of their sexual processes, the sexual stages are difficult to induce and are rarely observed. Descriptions of species therefore deal principally with various asexual structures, including the following:

Sporangiospores (asexual spores*) which are borne inside of a sac known as a sporangium; conidia (asexual spores) borne externally on the hyphae; thallospores which are actively reproducing cells formed by segmentation of the mycelium; and chlamydospores which are thickwalled, enlarged, resting spores also formed by segmentation of the mycelium.

4. Slime Molds: These organisms are characterized by the presence, as a stage in the life cycle, of an amoeboid multinucleate mass of cytoplasm called a plasmodium. The creeping plasmodium, which reaches macroscopic size, gives rise to walled spores which germinate to produce naked uniflagellate swarm spores or, in some cases, naked nonflagellated amoebae (myxamoebae). These usually undergo sexual fusion before growing into typical plasmodia again. The plasmodium of a slime mold is analogous to the mycelium of a true fungus. The slime molds are composed of 3 groups: The Myxomycatae (free-living plasmodia), Phytomyxinae (parasitic on plant tissue); and Acrasiae (plasmodia are formed aggregation of large numbers of independent myxamoebae.

Lower Protists (Bacteria and Blue-green Algae).

The bacteria, which include the rickettsia, form a heterogeneous group of microorganisms distinguished from higher protists by the following criteria: size range (0.2-2.0μ for the smallest diameter); procaryotic (simpler) cell construction and a unique system of genetic transfer (chromosome dynamics).

The blue-green algae include a variety of procaryotic forms which overlap bacteria and eucaryotic (possessing a true nucleus) algae in their range of cellular sizes. They are photosynthetic, possessing the same chlorophyll as the eucaryotic algae, and oxidizing H_2O to gaseous oxygen in their photosynthesis. By these properties (and other properties) they differ from the photosynthetic bacteria, which have specialized chlorophyll and do not produce gaseous oxygen.

Since bacteria are among the simplest of living organisms, it is easier to study in them the relationship of the external environment to the heredity. The effect of the environment upon the heredity can be observed only by noting the degree of change in the constitution and the reactibility of the organism. The changes in constitution and reactability (form and function) of a bacterium may be temporary or permanent. For example, the typhoid fever germ usually fails to ferment the sugar dulcitol, but when grown on a medium containing that sugar, colonies are produced which develop dulcitol-fermenting germs. If the modified germs be grown on these media over a long period of time, the successive generations have less and less tendency to revert to the original type. With such changes there usually also appears change in the structure of the organisms. The effect of the environmental impact on the genetic pattern of these organisms, therefore, is instrumental in producing changes in their constitution and

*The spores of fungi are exospores that grow on the exterior of the organism as distinguished from the endospores of bacteria which form in the interior of the organism.

reactability. Some changes are permanent because of changes in the genetic pattern of the cell (this is called an alteration of the genotype); some are temporary because no basic changes in the genetic pattern of the cell occur (this is called an alteration of the phenotype.) The age of the organism also effects its constitution and reactability, but is merely an expression of the development of the organism under the ever-changing relation between the external environment and the internal processes. The evidence indicates that there is a dynamic interdependence between the environment and the nature of the organism.

Miscellaneous Pathogenic Microorganisms That Are Not Precisely Classified.

Mycoplasma: These microorganisms are filterable. Their size ranges from 50 to 300 mu; some are larger. They grow and multiply on cell free media; are larger than viruses and extremely pleomorphic. They grow together with other bacteria and differ from bacteria in not having cell walls. They do, however, have a three-layered outer membrane similar to bacteria protoplasts (the structure of a cell without its cell wall). They are resistant to penicillin but not to tetracycline. Whether they are of bacterial origin is a question.

They produce pleuropneumonia (PPLO) in humans and cows. The human disease is known as atypical pneumonia. They also produce agalactia in sheep and goats.

Streptobacillus moniliformis, which produce rat-bite fever and Haverhill fever (a milk spread disease), respond to antibiotics.

Listeria monocytogenes are motile rods which are long and filamentous. These produce meningoencephalitis diseases in rabbit and chickens, and respond to antibiotics.

Erysipelothrix insidiosa produce erysipeloid skin infections in humans and in many animals, and respond to penicillin. These resemble Listeria.

Mimeae produce occasional hospital infection and respond to tetracyclines.

Bartonella bacilliformis are motile and pleomorphic, and are transmitted by the sandfly (Phlebotomus). They produce Oroya fever, a severe enemia in humans with a mortality rate of 40% when not treated. Also produce skin granulomas called verruga peruana, also transmitted by the sandfly. Respond to antibiotics.

Actinobacillus mallei and Pseudomonas pseudomallei produce glanders in man and horses, melioidosis in man, and may cause primary pneumonitis by inhaling the organism. Respond to sulfonamides.

Bacteroides are slender rods, fusiform, may be branching or round. May cause infection in many parts of the body, and respond to antibiotics.

Classification of Bacteria.

In contrast to the molds and yeasts, classification of bacteria on a morphological basis is difficult. Authorities neither agree on a phylogenetic or "artificial" classification. Bacteria are so small that morphological differences are inadequate as a basis for a workable classification. For larger grouping, some of the morphological characteristics used are shape, size, and grouping of cells. Gram stain and formation of spores are used also. However, finer subdivisions into species and varieties are largely made on the basis of physiological characteristics such as biochemical activities, pathogenicity, metabolic requirements, antigenic reactions, and reactions to the action of bacteriophages which are viruses pathogenic to bacteria. These viruses attack the bacteria and kill them by lysis. Many phages are known, each active against a specific species or even a strain of bacterium. This specificity has an important practical application in the phage typing of bacteria. Thus, types may be distinguished which otherwise are known to look and react alike. Phage typing has been used to distinguish the salmonellae and staphylococci, among which are forms capable of causing food-borne acute gastroenteric outbreaks.

Environment: The environmental factors which effect the growth and developement of bacteria are:

1) The degree of moisture in the surroundings.
2) The degree of temperature of the surroundings.
3) The degree of acidity or alkalinity (pH) of the medium.
4) The type of electrolytes in the medium.
5) The osmotic pressure of the medium.
6) The degree of oxygen (O_2) tension of the surroundings.
7) The degree of carbon dioxide (CO_2) tension of the surroundings.
8) The degree of other gas tension of the surroundings.
9) The character of the nutritive material in the medium, (vitamins, minerals, etc.)
10) The amount of exposure to various degrees of light.
11) The enzymes present in the medium.

Moisture: Water is necessary for the growth and development of all living matter. Pure water is a poor medium for growth and development because it contains none of the nutritive elements, such as vitamins, sugars, proteins, etc., and none of the chemical elements such as salts, acids and alkalies; nor is it conducive to the proper physical properties such as osmotic pressures, oxygen and carbon dioxide tensions, etc. Usually bacteria die in a dry environment. Some bacteria which have the ability to form spores, such as anthrox and tetanus bacilli, may remain viable for many years. Other non-spore forming bacteria may be kept alive by drying over an extended period of time. This depends on the medium in which they are dried, the rapidity of drying and other environmental factors. But viable dry bacteria do not grow nor reproduce; they hibernate so to speak.

Temperature: The life processes of bacteria are very sensitive to temperature. The bacteria which usually invade or live upon or within the human host have in most instances an optimum temperature for best growth and development which is close to that of the human body. Other bacteria which live on vegetable matter and are found in or upon the ground have an optimum temperature for growth and development which approaches that of the ground or the atmosphere. Thus, for most pathogenic bacteria the optimal temperature for growth is in the neighborhood of 37°C. and the range of temperatures over which growth occurs is approximately 15-40°C. There are many varieties of non-pathogenic organisms which have a similar temperature range for growth. There are also some bacteria which will grow at 0°C., while others known as thermophiles which have optimum temperatures of growth around 55°C. and may grow in temperatures as high as 75°C. Many of these latter types are found in milk which has been contaminated by soil, excreta, ensilage, etc. The human and bovine tubercle bacilli grow best at 37°C. and fail to grow below 30°C., the avian type of tubercle bacilli grows best at 40°C. and fails to grow below 30°C., while the cold blooded type such as found in fishes grows freely at 22°C.

Dry heat is not as good a means of destroying bacteria as moist heat. Whereas it takes a temperature of just over 100°C. for 1½ hours to destroy all vegetative bacteria by dry heat, and 140°C. for 3 hours to destroy all spores, it takes only a temperature of 105°C. for 10 minutes to destroy spores in moist heat. The greater the pressure under which the heat acts, the quicker the destruction of the bacteria. For this reason steam under pressure is the principle used in the autoclave for sterilization.

Acidity and Alkalinity or pH: The pH represents the strength of acid or alkaline reaction of a medium. When acids or alkalies are dissolved in water they dissociate into atoms or/and groups of atoms which carry negative and positive electrical charges. These are called ions. Example: $HCl \rightleftharpoons H^+$ and Cl^- which means that hydrochloric acid in solution dissociates into hydrogen ions with positive electrical charges and chlorine ions with negative electrical charges. Another example: $NaOH \rightleftharpoons Na^+$ and OH^- which means that sodium hydroxide dissociates into positively charged sodium ions and negatively charged hydroxyl ions. The double arrows

indicate a continuous process back and forth of dissociation and recombination. The characteristic of an acid is that when it dissociates it yields positively charged hydrogen ions. It is these ions which determine the fact that it is an acid. The characteristic of an alkali is that when it dissociates, it yields negatively charged hydroxyl (OH) ions. These ions determine the fact that it is an alkali. The degree of dissociation of an acid or alkali may be more or less, in which case the weak acids or alkalies are the ones which dissociate less and the strong ones which dissociate more. Thus, the hydrogen-ion or hydroxyl-ion concentration depends upon the degree of dissociation of the acid or alkali respectively. Therefore, equal quantities of different acids or alkalies will be weaker or stronger, depending upon their inherent ability to dissociate into more or less ions. For example, if equal quantities of hydrochloric acid, acetic acid, and boracic acid are put into solution, the hydrochloric acid will be the strongest acid, acetic acid will be next, and then boracic acid, because hyrochloric acid dissociates into ions more than the latter two acids, while boracic acid dissociates least. The same reasoning is applicable to strong and weak alkalies.

A solution is truly neutral when it contains an equal number of hydrogen and hydroxyl ions. Pure distilled water is neutral. Analyses have shown that at 22°C. it contains approximately 0.0000001 gram of hydrogen ions in a liter. This may be written: 10^{-7} (or its reciprocal $\frac{1}{10^{7}}$) gram hydrogen ions per liter. Inasmuch as a neutral solution contains equalnumbers of hydrogen and hydroxyl ions, pure water must also contain 10^{-7} gram of hydroxyl ions per liter. The chemist has discovered that the hydrogen ion concentration times the hydroxyl ion concentration of any solution is equal to a constant approximately equal to 10^{-14}. Therefore, if the hydrogen or hydroxyl ion concentration of any substance be known, the unknown can readily be calculated. If the hydrogen ion concentration of a solution be 10^{-4} , the hydroxyl concentration would be 10^{-10}. Using this information we may make the following scale to indicate the gradation of acidity of solutions:

$$10^{o},\ 10^{-1},\ 10^{-2},\ 10^{-3},\ 10^{-4},\ 10^{-5},\ 10^{-6},\ 10^{-7},$$
$$10^{-8},\ 10^{-9},\ 10^{-10},\ 10^{-11},\ 10^{-12},\ 10^{-13},\ 10^{-14}.$$

The larger the numerical value of the negative exponent, the smaller the hydrogen ion concentration and the greater the hydroxyl ion concentration. Example 10^{-1} is greater than 10^{-7}, because 10^{-1} is equal to $\frac{1}{10}$ or 0.1, whereas 10^{-7} is equal to $\frac{1}{10,000,000}$ or 0.0000001.

Such numbers are cumbersome to handle, hence Sorensen suggested that only the exponents be used, and these be expressed as positive instead of negative numbers. These exponents could be expressed in terms of the potential of hydrogen or hydroxyl. If the word potential be abbreviated by p, then the "potential of hydrogen" could be designated as pH, and the "potential of hydroxyl" as pOH. In order to simplify matters even further all acid or alkali strength is expressed only in terms of pH. Thus, a neutral solution which has a hydrogen and hydroxyl ion concentration of 10^{-7} or 0.0000001, may be expressed by a positive term, pH 7, and an alkali solution with a hydrogen ion concentration of 10^{-9} or 0.000000001 may be expressed by a positive term, pH 9. It is clear then that the pH value is the logarithm* of the reciprocal of the concentration of hydrogen ions. Written in terms of pH values, the scale becomes:

increasing acid strength	= acid reaction
pH 0, 1, 2, 3, 4, 5, 6, ←	= acid reaction
p^{H} 7	= neutral
pH 8, 9, 10, 11, 12, 13, 14 →	= alkaline reaction
increasing alkaline strength	

* A logarithm may be described as a power to which a fixed number must be raised to produce a given number. For example, if we choose 10 as the fixed number, the logarithm of 1000 is 3 because 10 x 10 x 10 (which is the 3rd power of 10) is equal to 1000. If the hydrogen ion concentration of a solution be $\frac{1}{10^{7}}$, the reciprocal of this is 10^{-7}, and the logarithm of 10^{-7} is -7.

It is important to remember when using the pH scale that it is a logarithmic scale, where the values change much more rapidly than the figures seem to indicate. Thus a pH of 6.0 represents a hydrogen ion concentration of one-tenth of that of pH 5.0 and one - one hundredth of that of a pH value of 4.0, and so on up and down the scale. It must further be remembered that because the pH values are actually negative logarithms, the larger the pH value the smaller the hydrogen-ion concentration.

For any given species of bacterium there is an optimal and relatively narrow range of pH allowing vigorous growth. For most of the bacteria associated with the bacteriology related to the human being, the optimum pH is a little to the alkaline side of neutrality (pH 7.2-7.6). The range over which growth is possible for most pathogenic bacteria is probably between pH 5.0 and pH 8.0.

Electrolyte: An electrolyte is a compound which dissociates in water into positive and negative electrically charged parts which migrate to the oppositely charged poles or electrodes when an electric current is passed through the solution. Since all living material is electrically charged, and since the fundamental processes of metabolism are electrical in nature, it is evident that the compounds in the living matter which carry the electric charges are of fundamental importance to the growth and development of organisms. Thus the various salts in varying quantities are of importance for the growth of various species of bacteria. Some of the salts are favorable for growth in one medium and the same salt in another medium may be toxic. Certain concentrations of table salt, NaCl, may cause rapid death to the meningococcus organism, but when a calcium salt is added the lethal effect is neutralized. It can be seen from this that the interchange of the electrically charged particles of electrolytes plays a decisive role in the life process of bacteria.

Osmotic Pressure: Osmosis is the selective flow of certain components of a solution through a semi-permiable membrane. The direction and the amount of flow through the membrane depends not only on the size of the molecules on either side of the membrane, but on the nature of the solute, the solvent, and the membrane itself. Other factors being neutral, more molecules will pass from the side with greater numbers per c.c. (smaller sized molecules) to the side with less numbers per c.c. (larger sized molecules.) When all the flow is over, there will be a difference of pressure between the two sides of the membrane. This difference of pressure is called the osmotic pressure.

All bacteria have membranous covering. But they differ from practically all other living cells in being profoundly indifferent to changes in osmotic pressure. The salts have no direct action of this nature on bacteria; they may exert an indirect action by causing a dehydration (loss of water) of the proteins on which the organisms are growing. It is this dehydrating action of salts which is relied on in many processes of food preservation.

Oxygen Tension: Among the most important of the gaseous requirements of bacteria is the preference shown by many species for particular ranges of oxygen (O_2) pressure, and the inability of certain species to multiply in the presents of this gas. On this basis it is customary to divide bacteria into three categories;

1) Obligatory anaerobes: Those which will grow only when molecular or gaseous oxygen is rigorously excluded. These utilize only compounded oxygen such as in $NaNO_3$.
2) Facultative anaerobes: Those which will grow both when molecular oxygen is present or absent. These may utilize compounded oxygen.
3) Obligatory aerobes: Those which will grow only when supplied with molecular oxygen.

Most bacteria belong to the second group and are able to grow over very wide ranges of oxygen pressures.

Carbon Dioxide (CO_2) Tension: There are many observations indicating that carbon dioxide is necessary for the growth of several, perhaps all, bacteria species including anaerobes. Lack of CO_2 will often prevent the multiplication of the bacilli of typhoid fever, anthrax, diphtheria, gas-gangrene, the common bacilli of the colon, etc.

Nutrition: Perhaps the most striking feature of the nutritional activities of bacteria is their extreme diversity. Unlike most plants and all animals, the nutritional mechanisms of the various

bacteria have no common pattern. It is clear that they have been evolved by selective adoption to the widest variety of environmental conditions, so that one species or another can take advantage of almost any possible type of food-stuff, and any biologically supportable environment. This ubiquitous colonization by bacteria as a class has been made possible only by a correspondingly wide differentiation in their metabolic activities, so that the nutritional needs of eacn bacterial group or species becomes a law to itself. Most bacteria can build up their carbohydrates, fats, and proteins from simple inorganic or organic substances. Tryptophane is the only amino acid which is essential to some bacteria. Some bacteria can synthesize their own tryptophane. There are indications that bacteria require certain vitamins for their growth.

Light: A very small group of bacteria have a photosynthetic type of metabolism, but most bacteria do not employ this mechanism. Photosynthesis is the process by which the green stuff (chlorophyll) of plants manufacture carbohydrates through the action of sunlight.

To most bacteria the ultra-violet rays of the sun or artificial light above a certain minimum level are lethal. Ultra-violet rays kill not only bacteria but almost all unicellular organisms including tissue cells of animals and plants; it is a protoplasmic poison. Since ultra-violet rays have a very poor penetrating power their action is mostly limited to the surface of an organism. These rays have not only a destructive effect on living cells but also on cell products such as protein. This is another reason for the lethal effect of light on bacteria, since the light may alter the nutritive medium in which bacteria grow in such a way as to render it poisonous. The length of time and the amount of light acting on bacteria or their medium determine the degree of its lethal effect.

Enzymes: An enzyme is an organic catalytic agent, i.e., it is secreted by living cells and has the power of inducing chemical changes in organic matter without apparently being changed itself. Yet there is some indication that certain enzymes may be changed while inducing changes in other substances.

Enzymes are of fundamental importance in the metabolism of bacteria as well as all living material. Metabolism concerns itself with a two fold process of synthesizing material (anabolism) and breaking down material (catabolism) for energy uses.

The reason that some bacteria are able to live as facilitative anaerobes is that they are able to change their enzyme systems to suit their environment.

The methylene blue test for determining the bacterial contamination of milk is possible because the methylene blue dye is sensitive to the enzyme, reductase, produced by the bacteria in the milk. The more bacteria in the milk the more bacterial enzyme is produced and the quicker the sensitive blue dye is changed to a colorless substance.

The test for adequate pasteurization of milk is also dependent upon measuring the presence of an enzyme. In this case the enzyme is one which is natural in raw cows' milk. The enzyme, phosphatase, is very sensitive to high temperature and will be devitalized at 143°F. for 30 minutes. It is indeed a remarkable co-incidence that the test is sensitive enough to show the lack of pasteurization if milk be held at 143°F. for 25 minutes, 141½°F. for 30 minutes, or if as little as 1/10 of 1% of raw milk be added to pasteurized milk.

The oxidation-reduction system of reactions is one of chemistry's most fundamental processes. (Oxidation is the removal of electrons from radicals and reduction is the adding of electrons to radicals.) This is a complementary system of processes. Where one process is present, so is the other. This complementary system is also found in the chemistry of organic material. The enzymes are substances which aid in initiating and carrying on these processes in living organisms. Bacteria as well as other living things have enzymes for digesting proteins, fats, carbohydrates and other organic substances. The action of enzymes demands optimum conditions of temperature, pH, electrolytes, etc., for most vigorous functioning.

The above discussion of environmental factors affecting the growth and development of bacteria gives an idea of the complicated system of conditions which affect the life of these apparent-

ly simple organisms. Yet the above discussion is elementary and far from complete. A detailed survey of the environmental factors affecting bacterial growth and development would be scarcely less an intricate and lengthy matter than one concerning higher forms of organisms.

Constitution

The interaction of the environmental forces and the forces of heredity results in the particular constitution and reactability of the bacteria. The usual constitutional characteristics used in identifying bacteria are: Size, Shape, Internal structure, Cell membrane, Cell capsule, Appendages.

Not considering the few very large bacteria and the group of very small ones, the average size would be about 1/5000 to 1/200 of a millimeter. Variability in size of the same species is a very common attribute; it is rather the rule than the exception. The variability in size of course is due to the complicated internal mechanism of reproduction and the influence of the environment on the reproductive, growth, and developmental processes.

Variability of shape is as universal among bacteria as variability of size. Some show little such variability, while for others such changes of shape are characteristic. The five generally recognized groups or families of bacteria classified according to uniqueness of form, are:

1) Spheroidal or coccal (meaning berry-like)
2) Cylindrical or bacillary (meaning rod-like)
3) Curved (or spiral), rigid rods: Spirillum (meaning coil).
4) Flexible, wavy or coiled, thread-like: Spirochetal (spiro meaning coil and chete meaning flowing hair).
5) Filamentous thread-like chains of rods.

Most bacteria derive their basic descriptive name from the above five classifications, as illustrated below:

1. Coccal bacteria assembled in grape-like groups are called Staphylococci (Staphyl meaning bunch of grapes). Diagrammatically they resemble:

In this group are found the bacteria which may cause food poisoning (Staphylococcus aureus and other types of staphylococci), boils and carbuncles (Staph. aureus, Staph. albus, Staph. citreus.)

2. Coccal bacteria assembled in groups of two are called Diplococci (Diplo meaning double). In this group are found the bacteria which may cause meningitis (Neisseria meningitidis), pneumonia (Diplococcus pneumoniae), gonorrhea (Neisseria gonorrheae). Diagrammatically they resemble:

3. Coccal bacteria assembled in chains are called Streptococci (Strepto meaning twisted). Diagrammatically they resemble:

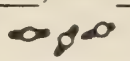
4. Sarcina (meaning bundle) bacteria are so named because they are assembled in bundles. Practically all of these are not disease producing in man. Diagrammatically they resemble:

5. Bacillary bacteria not arranged in any particular order are called Bacilli (meaning rods). In this group are found the bacteria which cause typhoid fever (Salmonella typhi), dysentery (Shigella dysenteriae), food poisoning (Salmonella group), Tuberculosis (Mycobacterium tuberculosis), diphtheria (Corynebacterium diphtheriae). Diagrammatically they resemble:

6. Bacilli arranged end to end in pairs are called Diplobacilli (Diplo meaning double). Practically all of these are not disease producing in man, but sometimes variations of pathogenic bacilli may resemble this group. Diagrammatically they resemble:

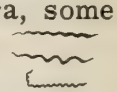
7. Bacilli arranged end to end in larger numbers than pairs to form filaments are called Streptobacilli (meaning twisted rods). These are sometimes classified as belonging to the group called Actinomyces (the filamentous-like group of bacteria). Haverhill fever is caused by Streptobacillus Moniliformis. Diagrammatically streptobacilli resemble:

8. Spore-bearing anaerobes. This group includes a number of disease producing germs such as the ones which cause tetanus (Clostridium tetani); gas-gangrene (Clostridium welchii, Clostridium

oedematiens, Cl. septique); food poisoning (Clostridium botulinum). Diagrammatically they resemble: 

Spore-bearing aerobes. In the spore-bearing aerobic group are found the bacteria which produce anthrax (Bacillus anthracis) and many non-pathogens whose habitat is the ground. These are bacteria which develop spores in an unfavorable environment. Diagrammatically they resemble:

9. Spirilla and Vibrio bacteria: In this group are found the bacteria which cause cholera (Vibrio cholerae). One of the spirilla has been found pathogenic for man and animals, that is, the one causing rat-bite fever (Sp. minus). Spirilla and Vibrio bacteria may be either comma or spiral shape. Diagrammatically they resemble:

10. Spirochetes: This group is not always classified as bacteria because the organisms have motility without possessing flagella. In this group are found germs which cause syphilis (Treponema pallidum), jaundice (Leptospira icterohaemorrhagiae), Yaws (Treponema pertenue), relapsing fever (Borrelia recurrentis). Spirochete germs are divided into sub-groups or genera, some of which are Treponema, Leptospiro, and Borrelia. Diagrammatically they resemble: 

11. Actinomyces (meaning ray-fungus, because they resemble ray-like filaments and were once thought to be fungi) are a group of thread-like bacteria which may be branched or unbranched, aerobic or anaerobic, spore or non-sporebearing. One member of this group produces actinomycosis in man and lumpy-jaw in cattle and swine. Some of this group have been found to produce offensive odor and taste in water. Diagrammatically they resemble:

Internal structure of bacteria had not been studied too well in the past due to the limitations set by their small size and the inability of the microscope to faithfully resolve images of bodies smaller than 0.2 μ (1/5000 of a millimeter) in diameter. The more recent use of the electronic microscope whose power is hundreds of times greater than the best lenses is giving aid in studying the internal structure of cells. A micron, symbolized by the Greek letter μ, is equal to 1/1000 of a millimeter or 1/25,400 inch. The majority of bacteria measure approximately 0.5-1.0 x 2.0-5.0 microns, staphylococci having diameters 0.75 μ and larger; rods like Salmonellae ranging in width from 0.5 to 1 μ and in length from 2 to 3 μ. Filamentous bacteria may be extremely long. The single cell is not visible to the naked eye, the visual acuity of the naked eye being approximately 75 μ.

Some observers believe that the bacterial cell is, like every other cell, differentiated into a nucleus (a mass of differentiated protoplasm which serves as the executive center of cell activity) and cytoplasm (the rest of the material of the cell). Others believe that the bacteria are homogeneous organisms not differentiated into nucleus and cytoplasm. But the most recent view is that the bacteria contain cytoplasm and nuclear material scattered through it and not aggregated into a mass as the nucleus is usually defined.

Besides nuclear granules, the bacteria contain other granules such as carbohydrate (glycogen), fat and lipoid substances. The function of these granules is not known but they probably serve as the substance involved in the metabolic process of the cell.

Some bacteria have the power of forming spores which is a protective function. The spore consists of the aggregation into one mass of all the nuclear-like material and becoming surrounded by a membrane which prevents agents such as heat from destroying its life at the ordinary thermal death point of the non-sporing stage. The spores may form at the end of the bacteria, in the middle, somewhere between the middle and the end, or the whole bacterium may become changed into an ovoid shaped spore. Example:

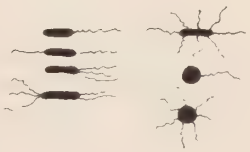
The spore is evidently a resting stage of these particular types of bacteria in which it is far more resistant to adverse environmental conditions than in its ordinary spore-free vegetative stage. Under favorable conditions they usually dissolve their spore-envelope and

proceed to reproduce, grow and develop.

The Cell Membrane is the outer cover just as the skin is the outer cover of animals. The membrane is very elastic and able to resist pressure, tension or torsion. Its structure is probably that of a mesh.

The Cell Capsule is an outer mucilagenous covering of some bacteria such as the ones which cause pneumonia and anthrax. It is a thickening of the outer cover probably developed by secretions from the cell.

Appendages. One of the means of movement of bacteria is by hairlike out-growths from the cyto-plasm of the cell. Such an appendage is called flagellum. A great number of bacteria have no flagella. Some have one, some two, and some more than two. A few coccal forms, many types of bacilli, most known spirilla and vibrios are more or less motile by means of flagella. Example:



Reactability

Having surveyed the constitutional characteristics of bacteria, we may now turn to consider the various characteristics of the bacteria which are due to their reactability to their environment. Reactability cannot be separated from constitution. Each depends on the other. The above constitutional characteristics which were discussed are, in spite of environmental influence, the inherited traits of all bacteria and serve as a general basis for classifying them. In the same sense, there are certain characteristic reactions, in spite of environmental influences, which are inherent to bacteria and serve as criteria for identifying them. These characteristic reactions are:

1) Colony Formation and cultural reaction.
2) Reaction to selective and indicator media.
3) Spore formation.
4) Pigmentation.
5) Cell-aggregation.
6) Motility.
7) Capsular swelling (Quelling).
8) Enzyme reaction.
9) Staining reaction.
10) Fermentation reaction and other biochemical properties.
11) Serological reactions.
12) Pathogenicity.

Colony Formation. When bacteria are seeded sparsely over the surface of solid media, the individual germs multiply and form isolated colonies. The appearance of these colonies is, in many cases, highly characteristic of the group or species to which the original bacterium belonged. The character of the colonies produced by a given bacterial species is of great importance in identification. Colonies are identified as to their shape, size, elevation, structure, color, transparency, surface, edge consistency, emulsifiability and character of central and peripheral areas. The character of the colonies will depend on the type of medium used.

When the bacteria are stabbed into a solid medium with a thin rod no distinct colonies will develop, but growth will take place along the line of puncture of the medium in most cases. Here should be noted the degree and extent of growth, the presence of a surface growth, the presence or absence of liquefaction of the medium, the presence of gas formation.

In fluid media, colony formation is not distinguished grossly, but the clearness or turbidity of the media and gas formation shoud be noted.

Reaction of Selective Media and Indicator Media. Selective media are utilized because they contain substances that have a stimulating effect on the growth of the bacteria that we desire to cultivate, or an inhibitory effect on the growth of others not desired to cultivate. The result in either case is selective growth of the particular organism that is being sought. Blood serum, tissue fluid, various sugars and salts, aniline dyes, phenol and numerous other substances are frequently used to stimulate or inhibit the growth of certain organisms.

Indicator media are those which contain an indicator (a substance which changes color when alkalinity or acidity is changed or when certain other chemical changes take place) which changes color when a certain organism or group of organisms grow and develop upon it. For example, if

it be known that the bacteria which we desire to cultivate produce hydrogen sulphide (H_2S), lead acetate may be added to the media and when the H_2S is developed the colonies become colored brown.

Sometimes selective and indicator media are combined in one medium.

Spore (endospore) Formation. This reaction of some bacteria has been previously discussed in considering the internal structure of bacteria. Since structure and function are so interdependent it is difficult sometimes even abstractly to discuss the one without considering the other. The function of spore-formation is a character which not many of the bacteria possess. It is a protective mechanism as far as can be ascertained, since it is usually, only under adverse environmental conditions that spores are formed. In this apparently dormant stage of the bacteria, they are able to withstand unfavorable conditions with much resistance. For example, heating a mixed culture of many types of bacteria at 80° C. for 10 minutes will destroy all vegetative non-sporing bacteria, while spores remain uneffected. Thus in milk which has been contaminated from soil or feces, there may be found a group of bacteria which is well able to withstand heat. Among these heat-loving bacteria or thermophiles, many are spore-bearing, grow best at temperatures around 60° C., and some even withstand boiling. Such a bacterium is Bacillus subtilis. Not all thermophilies belong to the bacillus group; many species appear to be streptococci, and even apparently non-sporing rods. Pasteurization of milk does not destroy them and therefore it is important that milk used for pasteurization should be clean and have a low bacterial count before pasteurization if the pasteurized milk be expected to have low bacterial counts. There are other bacteria which will spore at adverse low temperatures. The spores of bacteria are called endospores because they form in the interior of organisms as distinguished from the exospores which grow on the exterior of the fungi.

Pigmentation. Many bacterial species produce distinctive pigments which pigment sometimes, as with Staphylococcus aureus (producing a yellow pigment) remains within the bacterial cells, and sometimes, as with Pseudomonas pyocyanea (producing a bluish-green pigment) diffuse throughout the medium upon which it grows. This is an aid in identifying bacteria.

Cell Aggregation. This property of bacteria has already been discussed in considering the various forms of bacteria. Staphylococci usually aggregate in grape-like bunches, but under certain circumstances may appear as diplococci or without any form of aggregation.

Motility. The motility of bacteria is another method of identifying various types. The usual means of motility is by hairlike outgrowths called flagella. Such bacteria as those producing typhoid fever (S. typhosa), some of those ordinarily found in the intestinal tract (B. coli) and many other actively propel themselves through fluid media by means of flagella. The passive movement of bacteria in fluid media due to Brownian movement (molecular motion of the media) must not be confused with self-impelled motility.

If we consider spirochetes as bacteria we may define active motion in this case as due to the undulating movement of the whole body of the organism (like the movement of an eel or snake). Spirochetes do not have appendages such as flagella. Thus, motility in bacteria may be due either to undulating body motion or flagellar movement.

Capsular Swelling. Not all bacteria have capsules. Among the ones which do have capsules, the pneumococci (pneumonia producing bacteria) are the most important. The capsular swelling among these bacteria is one method used in identifying the various types.

Enzyme Reaction. - See previous discussion on enzymes.

Inhibitors. Inhibitors may have a pronounced effect on bacterial multiplication and death. Inhibitors may be a part of the food we consume; they may develop as a product of the microorganism's metabolism; they may develop during food or drink processing; or they may be purposely added to edible or drinkable materials.

Some examples of natural inhibitors are: benzoic acid in cranberries, lactenins and anticoliform factors in freshly drawn milk, and lysozyme in egg whites. Inhibitory substances developed by microorganisms during their multiplication may accumulate and become toxic. An example is alcohol produced in the growth and fermentation of yeast, in fruit juices, or in the production of wine. Substances not inhibitory to the organism producing them may be inhibitory to other organisms. This fact is very important when different kinds of microorganisms are in competition while growing. Other inhibitory substances include acids, peroxides, and antibiotics. Seldom will a contaminating microorganism find itself without competition from other kinds of microorganisms. Such interactions fall into three general categories: metabiosis, synergism, and antagonism.

In a metabiotic relationship, one type of microorganism makes conditions favorable for the growth of another. Many examples of these interactions are known such as fermentations and decompositions of raw food materials. In the natural souring of milk, a variety of different bacteria produce the acid at the early stage of souring. During the later stages, usually one Streptococcus survives.

In synergetic interactions, organisms act cooperatively and achieve what neither can do alone. Colors may be produced in the medium which are different from what either organism can produce by itself. The toxin C. botulinum, Type E, when produced in a fish product is activated by the activity of another Clostridium which releases an enzyme that enhances the toxicity of the toxin.

In antagonistic interactions, the microorganisms are in life-or-death competition for nutrients, for changing the pH of the medium to the disadvantage of the other, or the production of antibiotics by one to the disadvantage of the other.

Clostridium botulinum may be adversely affected by other bacteria, which may limit the germination of spores and vegetative growth of this organism or may destroy its toxin as rapidly as it forms. An antibiotic active against C. botulinum is formed by Brevibacterium lineus, a bacterium important in the ripening of Limburger cheese.

Inhibitory substances may develop during heat processing of foods. Inhibiting agents may be physical or chemical in nature, or a combination. The chemicals may be inorganic or organic in nature. Inorganic chemicals used to inhibit microbial multiplication are mainly certain inorganic acids and their salts. Gases, peroxides, halogens, metals, and alkalis and their salts are being used. Among organic substances are organic acids and their salts, alcohols, antibiotics, sugars, and formaldehyde. Many new compounds have been developed in recent years, and many are being developed right now. Irradiation is an inhibitory factor.

Staining Reaction. One of the greatest discoveries in bacteriology was that various types of bacteria, when subjected to various types of dyes, will become characteristically stained. By this method we are able to identify the various types of microorganisms. In some cases the whole bacterial cell may become uniformly stained. In some rod forms, the ends of the bacillus may become deeply stained, while the central portion may remain almost colorless; this is called polar staining, which is very characteristic of the plague bacillus (Pasteurella pestis) and is found in many other bacterial species. Sometimes the cell may stain unevenly throughout its length so that barred or beaded forms may occur, a feature which is very characteristic of the diphtheria bacillus and many allied organisms, and which occurs to a less marked extent with the bacilli of the tuberculosis and leprosy groups.

From simple staining, the technique has developed into many complex procedures. Two of the most common methods of staining which are generally employed in diagnostic procedures are:

1. Gram Stain. This reaction depends on the fact that, when certain bacteria are stained with certain aniline dyes, such as gentian-violet, methyl-violet and others, and are subsequently treated

with a solution of iodine in potassium iodide, a mordant action (fixing the stain fast)occurs which prevents the subsequent decolorization of the bacteria when treated with alcohol. Other bacteria, after similar treatment are readily decolorized. Those bacteria retaining the stain are called gram-positive bacteria; those not retaining the stain are called gram-negative bacteria.

2. Acid-Fastness. Certain bacteria, after being stained with warm solutions of fuchsin dye, resist the decolorization action of strong mineral acids. By this method of staining, the bacteria which belong to the tubercle bacilli (Tuberculosis) group can be identified. This group, then, is called the acid-fast group.

Fermentation Reaction and Other Biochemical Properties. In bacterial differentiation, the biochemical reactions of the bacteria to certain substances are often of the greatest importance. In many groups of organisms the classification is made on the basis of ability of the bacteria to ferment sugars or split proteins. The sugar tests especially afford a means of bringing out the finer distinctions between closely allied organisms. The ability of bacteria to cause oxidation of tartrates and citrates is employed in identifying the coliform group (bacteria found in feces, water and soil.)

Not only do the differentiation tests depend upon fermentation of certain carbohydrates and alcohols(colloquially spoken of as "sugars",)and upon the protein splitting powers of bacteria, but also on the ability to split fats, to reduce certain dyes such as methylene blue and litmus or certain salts such as nitrate and tellurite, to produce catalase (enzyme which decomposes hydrogen sulphide (H_2S)gas), to utilize certain salts such as tartrates and citrates, and to change the acid-alkali content (the pH) of glucose broth.

Serological Reactions. When germs attack the human being or other animals, the body is either overwhelmed by the attack and dies or else builds up a defensive and protective mechanism in the body which overcomes the adverse effects. This is known as the immunity mechanism of the body. This reaction which the germs produce in the body can be detected by certain technical examinations of the blood serum. The immune reaction causes certain elements to become present in the blood serum which are called antibodies. There are numerous such antibodies which an immune reaction produces;some are called agglutinins, others, precipitins, others antitoxin, etc. Each germ usually produces a specific group of antibodies. Because these antibodies are usually specific, they can be detected by certain tests and can give excellent information as to the type of germ which caused a particular disease. Some of the test which are based on this principle are the Wasserman test (for syphilis,)the Widal test (for typhoid fever,)the Schick test (for diphtheria,) the Dick test (for scarlet fever,) etc.

Pathogenicity (ability to produce disease.) The ability of bacteria to produce disease depends on the nature of their reaction in the body of the host. Some bacteria will produce disease in man but not in other animals; others will produce disease in various animals but not in man. Why one germ is pathogenic to man and another germ non-pathogenic is not exactly known, except that theoretically we may conclude that a substance is poisonous or a germ is pathogenic, depending on the inherent ability of the body of the host to resist unfavorable reaction.

Fundamentals of Bacterial Population Growth. Having considered the dynamic aspects of growth of bacteria in relation to environmental factors, let us now deal with the development and decline of bacterial populations.

If some bacteria be seeded into a liquid medium of suitable composition and incubated at a suitable temperature, it will be found that growth will follow a definite course. This course may be arbitrarily divided into 4 phases:

1) The lag phase, lasts for a few hours, during which multiplication is slow. In the early part of this phase there may be no apparent growth; in fact many of the organisms may die, so that there is an actual diminution in their numbers. This is probably due to the initial death toll resulting from the struggle of the organisms with the new environment. Altho growth in numbers is slow in this phase, there is an increase in size and activity. Each type or organism has a different duration for the lag period. The lag period will be shortest under the following conditions: a) If the inoculum be large, b) if the culture be young, c) if the culture be frequently transplanted, d) if the temperature be optimum, e) if the medium be optimum, f) if the inoculum be in the logarithmic phase.

2) The logarithmic phase is that period during which reproduction of organisms takes place at maximum speed. This phase lasts a little longer than the lag phase. The rapidity of reproduction will be greatest when: a) The temperature is optimum, b) the medium is optimum, c) the food supply is adequate therefore reducing the competition between organisms. Each type of organism has a different generation time.

3) The stationary phase is the next period during which the organisms cease to multiply at maximal speed, so their increase in number becomes less and less, till ultimately it ceases. The number remains approximately constant for an appreciable length of time. During this phase the number of freshly formed bacteria roughly counterbalance the number of those that are dying. The reason for this decline in the reproductive power of the organism is probably due to: a) The beginning shortage of food, b) increased competition between organisms, c) the development of an unfavorable environment due to crowding and accumulation of toxic materials.

4) The decline phase is the next period during which the organisms gradually diminish in number over an interval of days, weeks or months till all the organisms are dead. The reasons for this decline and self-sterilization appears to be due to: a) Exhaustion of foodstuff, b) concentration of population and the increase competition of the organisms to the point of a death struggle, c) accumulation of toxic waste products in the environment.

The growth curve of bacteria indicating the above four phases roughly resemble the following:

Growth Curve of Bacteria

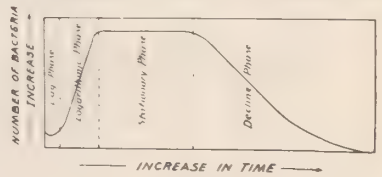


Fig. 1

Viruses

General Properties of Viruses

Viruses do not belong to the Protista kingdom. They are not cellular. Viruses are characterized by their ultramicroscopic size (up to 300 mμ) and by their ability to propagate only within living cells. The molecular weight of biologically active viral RNA* can range from as low as 1×10^6 daltons (One dalton equals the mass of one hydrogen atom) for bromegrass mosaic virus and 2×10^6 daltons for polio and influenza viruses to as large as 10×10^6 daltons for reoviruses. There is evidence that the secondary structure of reovirus RNA is a double-stranded helix. Most double-stranded DNA* animal viruses have a DNA molecular weight of the order of 4×10^6 daltons. They contain 1 type of nucleic acid and at least 1 antigenically active protein. At 1 stage of their replication they undergo conversion into a noninfective form which is an essential process of their growth cycle. The nucleic acid (the viral genome which is composed of the complete set of hereditary factors of the virus) causes the normal metabolic processes of the cell which it invades to be diverted into producing more viral nucleic acid and codes for a protein capable of forming an encasing shell or membrane, or capsid. The capsid stabilizes the viral nucleic acid so that it survives extracellularly and facilitates its adsorption to, and perhaps penetration of, susceptible cells. Much information on virus-host relationships has been obtained from studies on bacteriophages, the viruses which attack bacteria.

Plant viruses contain RNA. Poliovirus, mengovirus, influenza and Murray Valley encephalitis viruses are among the animal viruses which have yielded an infectious RNA. Papovaviruses, vaccinia and bacteriophage have yielded infectious DNA.

Because the active nucleic acid of a virus is covered by a protein membrane, the virus is not inactivated by specific enzyme, (i.e., ribo- or deoxyribo- nuclease) as is the active nucleic acid itself when freed from the protein covering. The antiserum neutralizes a virus because it reacts with the protein coat, but the same antiserum is without effect when in contact with viral nucleic acid.

*RNA is ribonucleic acid which together with DNA (deoxyribonucleic acid) form the heredity transmission material of life and composes the nuclear material of a cell.

Approximate diameters of certain disease-producing viruses in mμ:

Psittacosis group: Lymphogranuloma venereum virus, trachoma virus, inclusion conjunctivitis virus	300 mμ
Pox viruses: variola, vaccinia, ectromelia of mice, myxoma of rabbits, fowlpox, molluscum contagiosum	230 x 300 mμ
Rabies virus (a myxovirus?)	150 mμ
Myxoviruses: influenza, mumps, measles, rubella	80-250 mμ
Herpesviruses: herpes simplex, varicella, herpes zoster, cytomegalovirus, herpes B, pseudorabies	100 mμ
Adenovirus group	80 mμ
Reoviruses	75 mμ
Papovavirus group: Papilloma of rabbit and of man, polyoma or mice, vacuolating of monkeys	45
Arthropod-borne encephalitis and related viruses: (Japanese encephalitis, St. Louis encephalitis, Eastern equine encephalitis, West Nile fever, yellow fever	40 mμ
Picornavirus group: Enteroviruses (Poliomyelitis, Coxsackle, Echo), Rhinoviruses	18-30 mμ

Basis of Classification

The following properties, listed in the order of importance, has been suggested as a basis for the classification of viruses, although the amount of information available is not uniform for all viruses: (1) Nucleic acid composition; (2) Size and morphology, including type of symmetry, number of capsomeres (the protein sub-units of the capsid), and presence of membranes; (3) Susceptibility of physical and chemical agents, especially ether; (4) Immunologic properties; (5) Natural methods of transmission; (6) Host, tissue, and cell tropisms; (7) Pathology, including inclusion body formation; (8) Symptomatology.

Classification by Symptomatology:

A simple classification has been proposed which is based on the human diseases produced by viruses. While it offers certain conveniences for the clinician, it is not satisfactory for the biologist. Thus, in the classification below the same virus appears in different groups because it may cause more than one disease depending upon the organ attacked.

Generalized Diseases: Diseases in which virus spreads in the body through the blood stream and does not affect single organs only. Skin rashes may occur. These include smallpox, vaccinia, measles, German measles, chickenpox, yellow fever, dengue, Colorado tick fever, West Nile fever, sandfly fever, pleurodynia, and exanthem subitum; and rash due to enteroviruses, especially echoviruses 4, 9, 16, and 18, and coxsackieviruses A9, A19, B1, and B3.

Diseases Primarily Affecting Specific Organs: The virus may spread to the organ through the blood stream, along the peripheral nerves, or by other routes.

Diseases of the nervous system: Poliomyelitis, meningitis caused by the enteroviruses (polio-, coxsackie-, and echoviruses), rabies, encephalitis lethargica, arthropod-borne encephalitides, lymphocytic choriomeningitis, herpes-B; and meningoencephalitis of mumps, measles, vaccinia, and others.

Diseases of the respiratory tract: Influenza, bronchial pneumonia of children (RS virus, para-influenza), bronchiolitis (RS- Respiratory Syncytial- virus, para-influenza), laryngotracheobronchitis (para-influenza), pharyngo-conjunctival fever (adenovirus), common cold (caused by a number of different viruses, e.g., para-influenza, rhino-viruses and other picornaviruses), primary atypical pneumonia? (PPLO- Pleuropneumonia-like-organisms-a causative agent), psittacosis, and ornithosis.

Localized diseases of the skin or mucous membranes: Herpes simplex, molluscum contagiosum, warts, herpangina, and herpes zoster.

Diseases of the eye: Trachoma, inclusion conjunctivitis, adenovirus conjunctivitis, and Newcastle virus conjunctivitis.

Diseases of the liver: Infectious hepatitis and serum hepatitis.

Diseases of the salivary glands: Mumps and salivary gland virus disease (cytomegalovirus).

Disease of the lymph glands: Lymphogranuloma venereum.

Classification by Biological, Chemical, and Physical Properties.
Viruses can be clearly separated into groups based on the type of nucleic acid and on the size, shape, and substructure of the particle.

Psittacosis Group: These resemble small bacteria or rickettsiae. Although they grow intracellularly, they have a complex life cycle and are susceptible to the tetracycline antibiotics. They contain both DNA (deoxyribonucleic acid-the basic material of heredity in the nucleus of the cell) and RNA (ribonucleic acid-transmits information from DNA to the protein-forming system of the cell), and many enzymes.

Poxvirus Group: This includes members in many animal species where they are chiefly pathogenic for the skin. They are relatively large DNA viruses.

Myxovirus Group: Medium-sized viruses containing RNA and exhibiting helical symmetry. The diameter of the helix is 9 mμ or 18 mμ. The spherical viruses are about 100 mμ in size, but vary considerably from 80 to 300 mμ. Many particles are pleomorphic and not true spheres. Filamentous forms are common. Myxoviruses include influenza, para-influenza, respiratory syncytial, measles, German measles, (rubella), and mumps of man; and fowl-plague, Newcastle disease, distemper, and rinderpest in animals. They are primarily respiratory pathogens, but can spread systemically (mumps, measles, rubella).

Herpesvirus Group: Medium-sized viruses containing DNA and essential lipids, and exhibiting cubic symmetry in their protein shells. Latent infections may occur which could last for the lifespan of the host. Herpes simplex, herpes zoster, varicella, and cytomegalovirus infect man. Related members occur in monkeys, rabbits, cattle, horses, pigs, and fowl.

Adenovirus Group: Medium-sized, containing DNA and exhibiting cubic symmetry. Disease is rarely caused in laboratory animals, although types 12 and 18 produce tumors in newborn hamsters. For man, 28 types have been identified. They multiply in the nucleus. In man they have a predilection for mucous membranes, and may persist for years in lymphoid tissue.

Reovirus Group: Medium-sized, containing RNA and exhibiting cubic symmetry. Reoviruses were described as ECHO-10 viruses before their basic properties became known. Strains recovered from lower animals (chimpanzees, monkeys, cattle, mice) are indistinguishable from those of man.

Arbovirus Group: Over 150 arthropod-borne viruses are known which survive through a complex ecologic cycle involving biting insects. They multiply in a variety of species,

Chart I

Grouping of Communicable Diseases According to the Causative Agent

Bacilli

- Anthrax
- Acute bacterial conjunctivis
- Botulism
- Brucellosis
- Chancroid
- Diarrhea
- Diphtheria
- Dysentery (Shigellosis)
- Food Poisoning
- Glanders
- Granuloma inguinale
- *Rat-bite fever
- Leprosy
- Paratyphoid fever
- Pink eye
- Plague
- Pneumonia
- Salmonellosis
- Shigellosis
- Tetanus
- Tuberculosis
- Tularemia
- Typhoid fever
- *Vincent's infection
- Whooping cough

Vibrio

- Cholera

Streptococci

- Erysipelas
- *Food infection
- *Impetigo contagiosa
- Puerperal infection
- Rheumatic fever
- Scarlet fever
- Septic sore throat

Staphylococci

- Food poisoning
- *Impetigo contagiosa
- Staphylococcal disease in community, nursery, and surgical ward.

Spirochetes

- Leptospirosis
- Pinta
- *Rat-bite fever
- Relapsing fever
- Syphilis
- *Vincent's infection
- Yaws

Diplococci

- Gonorrhea
- Meningococci meningitis
- Pneumonia (lobar)
- Vulvovaginitis in children

Rickettsia

- Boutonneuse fever
- Colorado tick fever
- North Asian tick typhus
- Q fever
- Queensland Tick fever
- Rickettsialpox
- Rift Valley fever
- Rocky Mountain spotted fever
- Russian vesicular rickettsiosis
- Scrub typhus
- S. African tick-bite fever
- Trench fever
- Typhus fever, epidemic & endemic

Fungi

- Actinomycetoma
- Actinomycosis
- Aspergillosis
- Blastomycosis
- Candidiasis
- Chromoblastomycosis
- Coccidioidomycosis
- Cryptococcosis
- Dermatophytoses (Ringworm) Body, Foot, Nails, Scalp
- Favus
- Histoplasmosis
- Mycetoma
- Nocardiasis
- Para-coccidioidal granuloma
- Sporotrichosis
- Torulosis

Roundworms

- Acanthocheilonema
- Ascariasis
- Canine hookworm
- Dracontiasis
- Filariasis
- Gongylonemiasis
- Gnathostomiasis
- Haemonchiasis
- Hookworm (ancylostomiasis)
- Loiasis
- Mansonella ozzardi
- Metastrongyliasis
- Onchocerciasis
- Pinworm (oxyuriasis, enterobiasis)
- Strongyloidiasis
- Syngamiasis
- Trichinosis
- Trichostrongyliasis
- Thelaziasis
- Visceral larva migrans
- Whipworm (Trichuriasis)

*Diseases with several causative agents.

Filterable Viruses

Arthropod-borne viral encephalitides
- Diphasic meningoencephalitis
- Eastern Equine
- Japanese B.
- Louping Ill
- Murray Valley
- Powassan
- Russian Spring-summer
- St. Louis
- Western Equine

Arthropod-borne viral fevers
- Bunyamwera
- Bwamba
- Colorado tick
- Dengue
- Chikungunya
- Mayaro
- O'nyong-nyong
- Rift Valley
- Sandfly (phlebotomus)
- Venezuelan equine
- West Nile
- Group C viral fevers

Arthropod-borne viral hemorrhagic fevers
- Argentinian & Bolivian
- Crimean
- Kyasanur Forest disease
- Omsk
- Philippines & S. E. Asia with Renal syndrome with Uremic syndrome
- Yellow fever

Acute viral respiratory diseases
- Aseptic meningitis
- Cat scratch fever
- Chickenpox
- Common cold
- Cowpox
- Diarrhea
- Ecthyma, contagious
- Foot and mouth disease
- Herpangina
- Herpes
- Inclusion conjunctivitis
- Infectious hepatitis
- Infectious keratoconjunctivitis
- Influenza
- Lymphocytic choriomeningitis
- Lymphopathia venereum
- Measles
- Milker's nodules
- Mononucleosis, infectious
- Mumps
- Ornithosis
- Pleurodynia
- Pneumonia
- Poliomyelites
- Psittacosis
- Rubella
- Serum hepatitis
- Rabies
- Smallpox
- Trachoma

Protozoa

- Amebiasis
- Anaplasmosis (Texas Tick fever)
- Balantidiasis
- Leishmaniasis (visceral and cutaneous)
- Malaria
- Sarcocystiasis
- Toxoplasmosis
- Trichomoniasis
- Trypanosomiasis (African and American)

Arthropods

- Fleas
  - Chigoe infection
  - Flea-bite irritation
- Flies
  - Myiasis
- Lice-
  - Pediculosis
- Mites
  - Comedones (acne-like infection)
  - Mite-itch of various types
  - Scabies
- Spiders
  - Spider-bite poisoning
- Tick
  - Tick-bite poisoning

Flukes

- Amphistomiasis
- Clonorchiasis
- Echinochasmiasis
- Echinostomiasas
- Fascioliasis
- Fasciolopsiasis
- Heterophydiasis
- Opisthorchiasis
- Paragonimiasis
- Schistosomiasis

Tapeworms

- Cysticercosis
- Dipylidiasis (dogs and cats)
- Diphyllobothriasis (fish)
- Echinococcosis (sheep, cattle, hogs)
- Hymenolepiasis (rats, mice)
- Taeniasis (beef, pork, and duck)

Miscellaneous Pathogens

- Acute diarrheal disease
- Bacteroides infection
- Bartonellosis (Oroya fever)
- Erysipeloid
- Granuloma inguinale
- Haverhill fever (rat-bite fever)
- Listeriosis
- Mimeae infections
- Mycoplasmal (PPLO) pneumonia

Diseases in Man Caused by Arthropod-Borne Viruses

Virus Group	Name of Virus	Vector	Disease in Man	Where Found
Group A	Chikungunya (TH-35)	Mosquito	Fever, hemorrhagic fever	Africa, S. E. Asia
	Eastern equine	Mosquito	Encephalitis	Americas
	Mayaro (Uruma)	Mosquito	Fever	S. America
	Mucambo	Mosquito	Fever	S. America
	O'nyong-nyong (Gulu)	Mosquito	Fever	Africa
	Ross River	Mosquito	Fever	Australia
	Semliki Forest	Mosquito	Fever	Africa
	Sindbis	Mosquito	Fever	Africa, India, Malaysia, Philippines, Australia
	Venezuelan equine	Mosquito	Fever, encephalitis	S. America, Mexico, USA
	Western equine	Mosquito	Encephalitis	Americas
Group B	Bat salivary gland	Unknown	Fever, asceptic meningitis	USA
	Dengue 1, 2, 3, 4	Mosquito	Fever	Where mosquito vectors survive in large numbers all year
	Dengue 3, 4, ?5, ?6 or 1,2	Mosquito	Hemorrhagic fever	Where mosquito vectors survive in large numbers all year
	Diphasic meningoencephalitis	Tick	Encephalitis	USSR, Europe
	Ilheus	Mosquito	Fever, encephalitis	S. America, C. America
	Japanese B	Mosquito	Encephalitis	Asia
	Kyasanur Forest	Tick	Hemorrhagic fever	India
	Langat	Tick	Fever, encephalitis	Malaysia
	Looping ill	Tick	Encephalitis	G. Britain
	Murray Valley	Mosquito	Encephalitis	Australia
	Negishi	Unknown	Encephalitis	Japan
	Omsk hemorrhagic	Tick	Hemorrhagic fever	USSR
	Powassan	Tick	Encephalitis	Canada, USA
	Russian spring summer	Tick	Encephalitis	USSR
	Spondweni	Mosquito	Fever	Africa
	St. Louis	Mosquito	Encephalitis	Americas, Jamaica
	Uganda S, H-336	Mosquito	Fever	Africa
	Wesselsbron	Mosquito	Fever	Africa
	West Nile	Mosquito	Fever, encephalitis	Africa, India, Israel
	Yellow fever	Mosquito	Hemorrhagic fever	Africa, S. America
Group C	Apeu	Mosquito	Fever	S. America
	Caraparu	Mosquito	Fever	S. America
	Itaqui	Mosquito	Fever	S. America
	Marituba	Mosquito	Fever	S. America
	Murutucu	Mosquito	Fever	S. America
	Oriboca	Mosquito	Fever	S. America
Bunyamwera Group	Bunyamwera	Mosquito	Fever	Africa
	Germiston	Mosquito	Fever	Africa
	Guaroa	Mosquito	Fever	S. America
	Ilesha	Unknown	Fever	Africa
Bwamba Group	Bwamba	Mosquito	Fever	Africa
California Group	California	Mosquito	Encephalitis	USA, Canada
	Tahyna	Mosquito	Fever	Europe
Guama Group	Catu	Mosquito	Fever	S. America
	Guama	Mosquito	Fever	S. America
Sandfly Fever Group (Phlebotomus Fever)	Candiru	Unknown	Fever	S. America
	Chagres	Unknown	Fever	C. America
	Naples type	Phlebotomus	Fever	Europe, Africa, Asia
	Sicilian type	Phlebotomus	Fever	Europe, Africa, Asia
Simbu Group	Oropouche	Mosquito	Fever	S. America
Tarcaribe Group	Jumin, (Machupo)	Unknown,? Mite	Hemorrhagic fever	S. America
Miscellaneous and Ungrouped	Colorado tick fever	Tick	Fever	USA
	Crimean hemorrhagic fever	Tick	Hemorrhagic fever	USSR
	Hemorrhagic fever with renal syndrome	Unknown ?Mite	Hemorrhagic fever	Asia, Europe
	Quaranfil	Tick	Fever	Africa
	Rift Valley	Mosquito	Fever	Africa
	Semunya (Nakiwogo)	Unknown	Fever	Africa
	Vesicular Stomatitis, New Jersey type (Cocal)	Unknown,? Mosquito	Fever	USA, S. America

including man, horses, domestic and wild birds, bats, snakes, and in insects (mosquitoes, ticks). They are small-sized and contain RNA.

Papovavirus Group: At least 6 members of this tumorigenic group are known. They are small, containing DNA and exhibiting cubic symmetry. The human representative is the wart virus. Other members are papilloma viruses of rabbit and cattle, polyoma and K viruses of mice. Papovaviruses produce latent and chronic infections in their natural hosts. In recent years the simian papovavirus has been injected or fed to millions of persons as a contaminant of polio and adenovirus vaccines made in monkey tissue cultures.

Picornavirus Group: This group is subdivided into enteroviruses and rhinoviruses. At least 63 human enteroviruses have been typed; these include the polio-, coxsackie-, and echoviruses. Other types (including foot-and-mouth diseases) exist throughout the animal kingdom. More than 30 rhinoviruses have been isolated. They often cause colds, but certain enteroviruses can also do so. Picornaviruses are small, containing RNA and exhibiting cubic symmetry.

Metazoa

These are multiple-cell animal organisms. Among these are the worms or helminths which are divided into two groups, namely, the flatworms or Platyhelminths and round worms or Nemathelminths.

a) Flatworms include a large variety of tapeworms and blood and intestinal flukes.

b) Roundworms include those which cause hookworm disease, trichinosis, pinworm disease, common intestinal roundworm disease, filariasis, and a number of tropical diseases.

The Nitrogen Cycle

General Considerations. Elementary nitrogen constitutes 79 per cent of the earth's atmosphere and is characterized primarily by negative properties. It will not support combustion, will not support animal life, is not poisonous, combines directly with only a few other elements; it is mainly inactive. Indirectly, however, a relatively small proportion of the earth's nitrogen has been made to combine with many other elements to produce most extraordinary compounds. Of fundamental importance, combined nitrogen is the basis of living protoplasm, both plant and animal.

Though the general principles of growth and development relate to all forms of life, there are special types of activities which are inherent in special groups of organisms and are unique to these specific groups and to no other. Certain groups of bacteria have the special ability of changing organic nitrogen to inorganic, while other groups of bacteria have the special ability of changing inorganic nitrogen to the organic state. This continual change between the organic and inorganic state of nitrogen effected by bacterial action is called the "nitrogen cycle". This cycle is the chain of processes that links the inorganic and organic states of matter in the vast scheme of nature. It is one of the most important processes in the growth and development of living things. Without this special activity of certain bacteria the chain in the process of the continuance of life would be broken and living matter would disappear from the earth.

Ultimately, the nitrogen cycle is a biochemical process composed of a series of oxidation-reduction reactions in which microorganisms play a major role. Besides this cycle, there are cycles known as the carbon cycle, sulphur cycle and phosphorus cycle. But the nitrogen cycle is by far the most important, not only in relation to life, but also in relation to sanitary science, since it has special significance in determining the technique and design of such sanitary facilities and practices as the privy, the septic tank and disposal field, the Imhoff tank, the activated sludge system, the trickling filter, the sludge bed, disposal of sewage by dilution, stream pollution, the sanitary fill and composting methods of garbage disposal, all of which are, from a sanitary point of view, related to the process of self-purification.

Thus, the nitrogen cycle is a process by which simple inorganic nitrogen or nitrogen compounds are built up into complex living organic matter (protein in character) and then broken down into simple inorganic nitrogen or nitrogen compounds, etc. The building up process (anabolism) is dependent on bacterial activity and largely associated with plant life (but not always); the breaking-down process (catabolism) is chiefly brought about through bacterial action.

Nitrogen exists in plants and animals mainly in the form of protein. Protein which is eaten and not deposited as tissue is excreted as urea, hippuric or uric acid. Enormous quantities of nitrogen flow away in sewage or litter the earth as a result of dying plants and animals. If the nitrogen cycle were to stop, the pollution of water and soil would become very great in a short period of time due to cessation of the self-purification process. Life would soon cease due to toxic accumulations and to the failure of the rebuilding of nitrogen into protein which is essential to life.

Decomposition. As soon as plants and animals cease to live, there is initiated spontaneous chemical changes and also bacterial decomposition of an aerobic and anaerobic character. For the most part, decomposition results from the action of the myriad of bacteria and other creatures found in all soil and in natural waters. It has been found that bacteria inhabit only the upper layer of the soil, seldom occurring in any large numbers below the level of 2 or 3 feet from the surface. Good fertile loam may contain anywhere from 100, 000 to 500,000,000 bacteria per gram.

The bacteria causing decomposition are mostly saprophytes with nutritional habits of heterotrophs (bacteria which feed on complex organic carbon compounds,) but these are frequently capable of autotrophic existence (i.e., utilizing as food such simple inorganic substances as carbon dioxide, hydrogen, oxygen, sulfur, iron, water, and simple inorganic salts.) Among these bacteria there are numerous aerobic and anaerobic forms: cocci, bacilli and spirochetes. Each attacks one or more of the complex substances which compose dead plants and animals such as cellulose, bone, hair, protein, fats, and carbohydrates. The bacteria of the soil live in a constant state of mutual assistance, interdependence, competition and antagonism. One species may utilize and decompose the metabolic products formed by another, while another species may actually prey upon others or compete with others for the food that is available.

In considering the process by which organic materials are transformed into inorganic, we deal mainly with the following types of bacterial action:

1) Biological decomposition or decay (aerobic).
2) Fermentative decomposition (anaerobic).
3) Putrefactive decomposition (anaerobic).
4) Mineralization.
    a) Ammonification (aerobic).
    b) Nitrosification (aerobic).
    c) Nitrification (aerobic).

Aerobic decay refers to the bacterial break-down of organic material of all types by aerobic bacteria. The oxidative changes and great biological activity involved in this decomposition require a significant supply of oxygen from the atmosphere, and carbon dioxide is released to the atmosphere, and carbon dioxide is released to the atmosphere. In very rapid decomposition,

as in some composting procedures, a great deal of heat is liberated through the activity of thermophilic bacteria which may cause the temperature of the mass to reach a height of some 160° F. Commonly in nature this heat is released over a long time span, and in the case of trickling filters is dissipated with the water flow. The main products of decomposition under condition of complete oxidation are carbon dioxide and water.

Fermentative decomposition refers to specific break-down of carbohydrates by anaerobic bacteria with the formation of acids or acid like materials such as lactic acid, acetic acid, alcohol, carbon-dioxide, methane, hydrogen, etc. Putrefactive decomposition is literally a process of offensive decay. It is generally restricted to include only those processes of protein disintegration which give rise to foul smelling products. For practical purposes, it consists of the decomposition of organic matter of protein character by anaerobic bacterial action down to the process of mineralization. The steps in the decomposition of fatty substances are less known than that for carbohydrates and proteins. It appears that fats oxidize more slowly. One type of fat dries forming a tough coating. Another type of fat splits into fatty acids and glycerol by hydrolysis and then decomposes further by oxidation. Fat decomposition may either be chemical or bacterial action.

Protein Decomposition. In the process of self-purification we are mainly interested in protein decomposition which is one phase of a series of processes involved in the "nitrogen cycle". This process cannot be completely separated from carbohydrate and fat decomposition. These latter processes occur together and produce their effects on the process of protein decomposition.

The initial products of the aerobic decay of proteins and other nitrogenous material are the amino acids. There are some twenty-two of these so-called "simple proteins" which, combined in various ways, make up all plant and animal proteins. Although our knowledge of the chemistry of the early stages of protein decomposition is not ample, we do know that, in the putrefactive process, the protein is broken down by the action of anaerobic bacteria into such simpler substances as albumoses, proteoses, polypeptides, peptones, amino acids and other amino substances, hydrogen sulphide, organic acids, indole, skatole, and phenol.

When putrefactive bacteria attack dead animal or vegetable matter, they cause the protein material to be broken up into simpler products which strikingly resembles the digestion of protein in the stomach and intestines. Some of the putrefactive bacteria produce proteolytic (protein splitting) enzymes which liquify the protein. Other bacteria, of the type found in the large intestines, can break down protein without any evidence of liquefaction. For the most part, bacteria which are pathogenic for man are killed during the process of putrefaction. In order for processes of decomposition to take place, the protein material must contain the needed moisture, warmth, and other conditions essential for bacterial activity. The breaking down of vegetable matter is slower and more difficult than the breaking down of animal matter.

The process by which ammonia is released from decomposing organic nitrogen compounds is called ammonification, while the specific step in this whole process whereby the ammonia is split off and released from amino acids is called deamination. The ammonia thus released might escape to the atmosphere and be lost to the nitrogen cycle going on in the soil were it not for the fact that some of it forms ammonia salts (such as ammonia chloride and ammonia carbonate) and some of it is oxidized to nitrites by the bacteria of the genus Nitrosomonas. The ammonia salts are rather unstable and are also changed by the Nitrosomonas into nitrites. The Nitrosomonas have the ability also to take ammonia gas out of the atmosphere and change it to nitrites. This bacterial action of changing ammonia and ammonia salts to nitrites is called nitrosification. Thus, the ammonia gas is, for the most part, secured for maintaining the nitrogen in the soil. The nitrites formed in the process of nitrosification are practically useless to plants unless they are oxidized to nitrates. This step is carried out by the genus of bacteria known as Nitrobacter, and the process is called nitrification. Sometimes both the processes of nitrosification and nitrification are loosely spoken of as nitrification. Both processes are aerobic. We find, then, that protein decomposition begins by the aerobic process of decay and the anaerobic process of putrefaction and ends with the process of mineralization which is composed of the three aerobic processes of ammonification, nitrosification, and nitrification.

Mineralization. The process of mineralization begins in the latter part of the putrefactive process, when the complex products of protein decomposition have been changed into relatively simple products such as simple organic acids, indole, phenol and other amino substances, and finally into hydrogen sulphide, mercaptan, carbon dioxide, and ammonia. There is no definite point of demarcation between the two processes. The final stage of the mineralization process is when the organic products of decomposition have been transformed into minerals. There are several phases that stand out as important when related to the nitrogen cycle. The transition of ammonia and ammonium salts to nitrates was a mystery until, in 1888, Winogradsky made one of the most brilliant discoveries in bacteriology. Through his epoch-making work he showed that there are present in the soil and water, two distinct types of bacteria, one, the Nitrosomonas, which is capable of producing a special ferment that oxidizes ammonia and ammonium compounds into nitrites, and another, the Nitrobacter, which by a special ferment oxidizes the nitrites into nitrates.

Nature has a way of always countering one action by another of an opposite character. This may well be considered a fundamental law of nature. In this connection it might be pointed out that the process of nitrosification and nitrification are countered by another opposite process of denitrification by which certain aerobic and anaerobic bacteria are able to reduce nitrates back to nitrites, ammonia, or free nitrogen. This process becomes intensified where the soil is waterlogged, poorly aerated, and impregnated with much organic matter. This process has the effect of preventing the soil from becoming fertile.

Ordinarily, the nitrates go into solution in water and are either taken up by the roots of plants or are washed away. In a sanitary analysis of water taken from the soil, therefore, the presence of nitrites and nitrates are of special significance. If nitrites be found, it indicates pollution and signifies active bacterial action and the presence of organic matter. Nitrates in such water, without nitrites, are an index of past pollution, since we must expect that the process of nitrification had been completed and bacterial action on organic matter took place sometime in the past.

Thus far, the breaking down phase of the nitrogen cycle ends, and next begins the rebuilding phase of the cycle, i.e., the rebuilding of the inorganic nitrogen matter into complicated organic protein substances.

Nitrogen Fixation. The rebuilding of inorganic nitrogen material into complex organic matter which becomes plant protein is known as "nitrogen fixation." This process is carried on by bacterial action. Two great groups of bacteria possess this power. The members of one group (the genus Azotobacter) live free in the soil, are aerobic and are able with the energy they obtain from the oxidation of organic carbon to build up complex nitrogen compounds. They are able to obtain their nitrogen directly from the air, but prefer ammonia, and can utilize nitrates, nitrites, urea and asparagine. This is called "non-symbiotic" nitrogen fixation. In swampy soils where Azotobacter does not live, non-symbiotic nitrogen fixation is carried on by at least one species of anaerobes belonging to the genus Clostridium. The bacteria of the other group, the genus Rhizobium, are able to fix nitrogen by living in symbiosis (the mutually advantageous association of two or more kinds of living organisms) in the root nodules of certain plants, especially legumes (peas, beans, clover, lupines.) This genus is strictly aerobic. The nodules in the roots of plants are produced by the invasion of these bacteria into root tissues. The "Symbiotic" group fix only the nitrogen compounds found in the soil around the roots of plants. With the nitrogen fixation process, the nitrogen cycle is now complete. This chain of processes from organic nitrogen to inorganic and back again to organic, etc., is a most remarkable natural phenomenon.

It will be noted that, in the nitrogen cycle, all the essential steps are the result of bacterial action. Each stage of the complex process is specific in character, in the sense that each stage requires a particular species or group of bacteria to effect the result, and also specific in the sense that each stage requires special conditions of environment for its action to take place. The nitroso-bacteria, such as Nitrosomonas will build only nitrites. Nitrobacter is equally specific in oxidizing nitrites to nitrates, etc. The decomposition of protein occurs in stages as a result of bacterial action largely specific for each step. After decomposition is started,

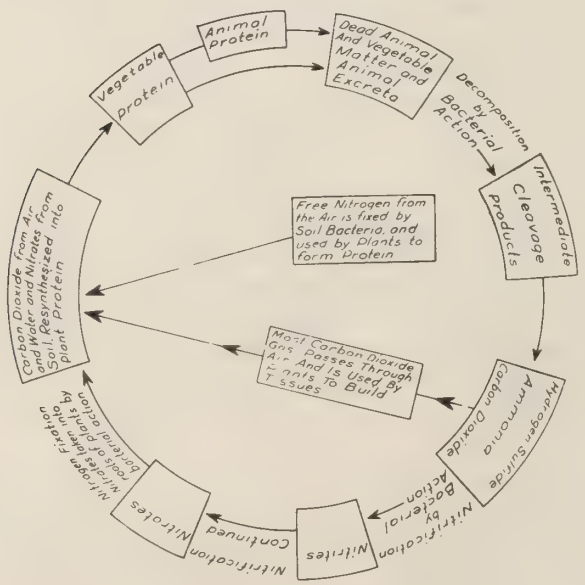
special organisms or groups continue the process step by step.

The rebuilding phase of the cycle in plants begins with the process of manufacturing complex energy-bearing substances from simple ones by means of chlorophyll using solar energy. Photosynthesis produces, together with other tissues, the amino-acids which are linked into the plant proteins typical of the plant species. This phase also includes the production of bacterial protein in the absence of sunlight with the required energy being supplied by various chemical reactions. Thus chemosynthesis and photosynthesis produce from simple substances the nitrogenous and other food substances on which all other life depends.

With the digestion, assimilation, and tissue building of animal protein from plant protein, the aerobic nitrogen cycle is completed. It is evident that, for the purpose of illustration, the cycle is idealized and it must be remembered that all phases of the cycle are always found occurring simultaneously. In addition, related cycles such as those of carbon, sulphur, and phosphorus occur concurrently, and in a decomposing mass and in the rebuilding phases appear as related processes as seen in the gas interchanges described in both the aerobic and anaerobic nitrogen cycles.

It is important to remember that practically the entire cycle takes place upon the surface in the upper layers of the soil. A few feet below the upper layer, the soil in an undisturbed area contains few or no bacteria. Excreta placed too far below the surface, does not profit by completing the nitrogen cycle, and under such circumstances incomplete nitri fication takes place. Nature's method of disposing dead waste is thereby defeated and pollution of the soild and contamination of ground water may result.

The sanitarian must take note that practically all of the artificial and mechanical processes that are used in public health for disposal of waste material are based on knowledge of the nitrogen cycle and the use of the process of putrefactive decomposition. An exception to this is the incinerator which destroys waste materials without the utilization of bacterial decomposition.


Animal protein
Vegetable protein
Dead Animal And Vegetable Matter and Animal Excreta
Decomposition by Bacterial Action
Intermediate Cleavage Products
Hydrogen Sulfide
Ammonia
Carbon Dioxide
Nitrification by Bacterial Action
Nitrites
Continued Nitrification
Nitrates
Nitrogen fixation Nitrates form by Bacterial action
Carbon Dioxide from Air and Water and Nitrates from Soil Resynthesized into plant Protein
Free Nitrogen from the Air is fixed by Soil Bacteria and used by Plants to form Protein
Most Carbon Dioxide Gas Passes Through Air And is Used By Plants To Build Tissues

The Nitrogen Cycle

Fig. 2

Chapter V

COMMUNICABLE DISEASE CONTROL

The control of diseases in human beings is fundamentally a program of struggling against and trying to prevent the occurrence of those circumstances in the human population which cause premature death and disability. But this "struggle for survival" of human populations cannot be separated from the struggles for survival of all other organisms on the earth. This is so because human individuals and human groups not only must struggle for survival against other human individuals and other human groups but also against organisms which do not belong to the human species, such as germs, rats, mosquitoes, ragweeds, and the like. The struggle for survival is not only a contention between living things, but also a struggle of living things with the physical and social environment, i. e., against such factors as drought and famine, poverty and poor housing, economic depressions and demoralization, climate, seasons, weather, certain customs and traditions, and hosts of other factors. The nature of these struggles must be known in order to understand the fundamentals of disease control. All this, therefore, is the subject matter of epidemiology, which may be defined as the science which concerns itself with the investigation of the relationships of organisms to organisms, and organisms to environment insofar as these relationships are concerned with the occurrence and spread of diseases. The scientific control of diseases is based on the evidence and theories developed by epidemiology.

Diseases occur because an individual or a group of individuals move into an unfavorable relation with the environment or with other individuals. This "unfavorable relation" may involve the individual's surroundings in the home, in the school, at work, during recreation, in the community where he lives, in the communities surrounding his community, in the communities which connect with his community by waterway, railroads, airplane, and other means of transportation; it may involve his physical and social relationships, direct and indirect, with other people; his relations, direct and indirect, with the plants, insects, and other animals; it may involve his relations to the weather, the climate, the seasons, the soil, and the air which continually affect him. One can see, then, that diseases result from the movement of people and the movement of environmental factors so that, at some point, an unfavorable relation develops.

The control of diseases depends therefore upon the epidemiological knowledge developed from a study of:

1. The organism's struggle with its physical environment, and in the case of the human being, also its social environment.
2. The organism's struggle with other organisms or the struggle of one group of organisms against another group.

Diseases are classified as communicable and non-communicable. Communicable diseases are ordinarily defined as those caused by germs which can be communicated directly or indirectly from individual to individual, while non-communicable diseases are all other diseases.

There is a very intimate relationship between the communicable and non-communicable diseases. Communicable diseases may produce non-communicable diseases. For example, rheumatic fever may produce the non-communicable rheumatic heart disease, diphtheria may weaken the heart muscle so that heart disease persists even though the diphtheria germs have long disappeared, and infectious hepatitis may injure the liver and produce cirrhosis of the liver some years later. Non-communicable diseases may predispose to communicable diseases. For example, malnutrition may allow many types of pathogens to invade the body and produce communicable diseases. Hookworm disease is much more prevalent among malnourished people than among well nourished people even though both be equally exposed to the infection. Silicosis predisposes to tuberculosis. Diabetes predisposes to various types of infections. Non-communicable diseases requiring absolute bed rest predispose to pneumonia. The wear and tear in the body from housing and exposure may injure the body enough so that pathogens may invade and produce communicable diseases. The interrelation between communicable and non-communicable diseases becomes more and more evident as the student ponders these problems.

A communicable disease therefore results from an unfavorable relation of movement between the host and the disease producing parasites in a particular environmental setting. The more favorable the environmental conditions the easier is the struggle of the host against the pathogen.

It is obvious that if disease producing parasites could not enter, multiply, and leave the host, they would be unable to enter other hosts, and there would be an end to communicable diseases. It is just this which we try to accomplish in the control of communicable disease; that is, we try to break the cycle at some point. This cycle which operates in the framework of the organisms struggle with the environment and with other organisms can be expressed in the following manner:

1. The ability of the parasite to enter the host;
2. The ability of the parasite to multiply in the host;
3. The ability of the parasite to leave the host;
4. The ability of the parasite to enter another host.

The first phase of the cycle can be broken by good sanitation and personal hygiene. The second phase of the cycle can be broken by building up resistance of the individual by nutrition, immunization, favorable living conditions and medical care. The third phase of the cycle can be broken by proper personal hygiene of carriers and sick persons, by good sanitation, or by death. The fourth phase is really the first phase of a new cycle and is therefore broken as described for the first phase.

Since the sanitarian's concern is the environment, it is his problem to know how diseases spread or why they occur in particular pattern of distribution so that he may introduce controlling measures into the environment to prevent the spread. The spread of parasites is due mostly to the movement of man, animals and non-living things such as, streams, winds, water in pipes, sewage, etc. Such non-living materials (poisons) as arsenic, lead, phosphorus, cadmium, and sodium fluoroacetate may also spread by communication among a group of persons; silicosis (a lung disease caused by silica dust) becomes distributed among civilized man because he communicates the technique of mining from country to country; pellagra occurs mostly among poverty stricken people because of the wide spread distribution of poor eating habits among them. Certain types of mental diseases may occur more among certain economic levels of society because of the unique distribution of circumstances among each level. More and more does the sanitarian become involved in sanitary matters concerning the control of non-parasitic diseases although most of his work is still concerned with the control of diseases caused by the communication of germs from person to person.

The fundamentals of sanitation are grounded in the manipulation of the environment so as to reduce to a minimum the effects of the spread of factors which cause stresses and strains on the individual and community, and in the regulation of human activity in such a manner as to prevent the spread of disease producing germs from one living organism to another. Therefore our various methods of sanitation depend upon knowing the history of the cycles of movement of the factors which cause disease or aid in the spread of disease. The history of the typhoid, cholera and dysentery germs tell us that they live in the intestinal tract of the human and pass out of the body with the contents of the bowel movement. For this reason a safe method for disposal of exereta is absolutely essential. We further know that water may harbor these germs over long periods of time and is therefore an effective vehicle for carrying them from one place to another. For this reason a safe water supply is necessary. The prevention of contamination of streams, the restricted use of streams for swimming and other purposes that may bring the individual into contact with the contaminated water, the necessity for good plumbing, safe wells, and efficient water works—all these measures must be observed. We also know that these germs may spread directly from one person to another. Therefore the isolation and hygiene of the infected person and proper supervision of carriers are of paramount importance.

We know that malaria, yellow fever and dengue fever are spread from person to person by means of very definite species of mosquitoes. If these particular kinds of mosquitoes could be controlled then the disease which they spread could be controlled. Therefore it is essential to drain swamps and ditches, to spray bodies of water, to devise methods to control the level of lakes and impounded waters, to facilitate drainage of refuse water from homes and factories, to screen homes, etc.

We know that tuberculosis, typhoid fever, scarlet fever, septic sore throat, dysentery, undulant fever and food poisoning are spread by milk, milk products and other foods. Therefore rigid control of the production and distribution of these products are essential to control their spread. Dairies must be supervised, cattle must be tested, dairymen must be examined, the production of frozen desserts, pastry and other foods must be vigilantly observed, and the distributors of these products, such as grocery clerks and waiters, must be under continual observation.

We know that hookworm disease spreads because of the lack of sanitary excreta disposal. Therefore the building of privies or other types of safe toilet facilities, are necessary to control the spread of this disease.

We know that trichinosis is spread by consuming infected hog meat. It is therefore necessary to control the production of pork products such as sausage and hams and to keep continual watch over those farms which raise hogs for public use. Humans who eat raw, partly raw, or poorly cooked hog meat that is infected with the trichina parasites will contract this disease. Hogs which are fed the uncooked refuse material from slaughter houses or garbage containing infected particles of uncooked hog meat, or rats which eat this material will contract trichinosis. Rats that eat rats or hogs that eat rats may become infected.

We know that human lice may spread typhus fever and trench fever, that the wood tick may spread rocky mountain spotted fever, that rat fleas may spread typhus, plague and rabbit fever (tularemia), that dogs and other animals may be reservoirs of rabies, that horses and fowl may be reservoirs and mosquitoes vectors of equine encephalomyelitis, etc. The more we learn of the history of diseases in insects and animals the more we learn how to control the spread of communicable diseases to man.

A common means of the spread of disease germs is by way of dishes, towels, toilet seats, bed clothing, etc. Therefore general care and cleanliness relating to these things are of utmost importance in control of many communicable diseases. Such diseases as the common cold, influenza, pneumonia, scarlet fever, dysentery and mumps may be spread by unclean dishes. Towels and bed clothes may spread tuberculosis, typhoid fever, measles, smallpox, chickenpox, and other infectious diseases.

It can be quickly gathered from all this that the sanitarian plays a fundamental role in the control of communicable diseases. It can also be seen what basic role excreta disposal and water supply control play in community sanitation. Schools and homes in rural areas and in depressed urban areas are generally handicapped by poor sanitation, usually due to bad economic conditions. But gradual improvement is possible with persistent effort.

When diseases are spread directly by contact from infected person to non-infected person or by transmission for short distances (about 3 feet or less) through the air by droplets, such mode of spread is denoted as direct. When diseases are spread from infected person to non-infected by means of contaminated surface articles, or matter or vehicles of infection, including floors, food, clothing and utensils, by means of air convection, or by means or arthropods or other animal vectors, such mode of spread is denoted as indirect.

Although, at present, communicable diseases do not take the greatest toll of life in such advanced countries as the United States, they do take the greatest toll of life if the whole world picture be considered. Nevertheless, the vigilance in keeping control methods functioning in the United States is of utmost importance, lest communicable diseases regain their previous ascendency.

Our knowledge of communicable disease control has grown tremendously in the past fifty years. This has been due to our growing understanding of the nature of disease producing germs and the movement of these germs in relation to the movement of human beings. Through knowledge of how they react in their host we have learned to counteract their reactions. The former knowledge has lead to effective sanitation and hygiene, the latter knowledge has led to methods of immunization and treatment.

The host-parasite cycle as described above, summarizes in a simple manner the very complicated nature of disease occurrence and spread in the process of the "struggle for survival."

Definitions.

Epidemiology - The science that concerns itself with the interrelationships of the various factors and conditions which determine the frequencies and distributions of an infectious process, a disease, or a physiological state in a human community. The same definition may also be applied to animal or plant populations.

Endemic - That circumstance whereby a disease exists in a certain place more or less constantly. In relation to animal populations, the term used is enzootic.

Epidemic - The occurrence of a disease, derived from a common or propagated source, and effecting such numbers of persons or animals within a limited period as to be considered unusual for that area. In relation to animal populations, the term used is epizootic.

Pandemic - Widespread epidemic, usually beyond national boundaries. In relation to animal populations, the term used is panzootic.

Etiologic Agent - That agent which causes disease.

Contamination -The presence of a pathogenic agent on a body surface of a living organism or on or in an inanimate article or substance.

Pollution - The presence, in a medium, of a foreign substance from animal or industrial sources, in such quantities as are objectionable or harmful or may possibly be harmful to life.

A Parasite is an animal or vegetable organism that lives on or within another organism from which it derives its food and is able to maintain its life processes.

A Host is an organism which harbors a parasite.

A Definitive Host is the host which harbors the adult parasite or where the sexual process of the parasite is carried on.

An Intermediate Host is the host which harbors the larvae of the parasite or where the sexual process of the parasite does not take place.

An Infection is a process whereby pathogenic bacteria enter into and multiply in the tissues of the body of man or animal.

An Infestation - The lodgment, development, and reproduction of arthropods on the surface of the body or on the clothing, or the harboring or sheltering of animal forms, especially arthropods on the surface of the body or on the clothing, or the harboring or sheltering of animal forms, especially arthropods and rodents, in articles or premises.

A Disease is a disturbance of function or structure of the body or part of the body.

Contact - Any person or animal known to have been in such association with an infected person or animal as to have been presumably exposed to infection.

Suspect - A person whose medical history and symptoms suggest that he may now have or be developing a case of some communicable disease.

Reservoir of Infection - The site in which an infectious agent lives and multiplies and depends primarily for survival so that it can be transmitted to man.

Vector - Arthropods or other invertebrates which transmit infection by inoculation into or

through the skin or mucous membrane by biting, or by depositing of infective materials on the skin or on food or other objects. The vector may be infected itself or may act only as a passive or mechanical carrier of the infective agent.

Vehicle of Transmission - Water, food, milk, biological products, or any substance or article serving as an intermediate means by which the infectious agent is transported from a reservoir and introduced into a susceptible host through ingestion, through inoculation, or by deposit on skin or mucous membrane.

Disinfection - Destruction of pathogenic microoorganisms by chemical or physical means directly applied.

Terminal Disinfection - The rendering of personal clothing and immediate physical environment of the patient free from the possibility of conveyiny the infection to others, after the patient has been removed, or has ceased to be a source of infection, or after isolation practices have been discontinued.

Concurrent Disinfection - Application of disinfection immediately after the discharge of infectious material from the body of an infected person, or after the soiling of articles with such infectious discharges, all personal contacts with such discharges or articles being prevented prior to such disinfection.

Disinfestation - A physical or chemical process serving to destroy undersired animal forms, particularly arthropods or rodents, present upon the person, or his clothing, or in his environment, or on domestic animals.

Fumigation - Any process by which the destruction of animal forms, especially arthropods and rodents, is accomplished by the employment of gaseous agents.

Sterilization - Is any chemical or physical process which destroys all microorganic life.

Isolation - The separation for the period of communicability of infected persons from other persons, in such places and under such conditions as will prevent the direct or indirect conveyance of the infectious agent from infected persons to other persons who are susceptible or who may spread the agent to others. This also applies to animals.

Modified Isolation - When protection against the spread of a particular disease does not require all the provisions required for strict isolation.

Quarantine - Complete quarantine is the limitation of freedom of movement of such well persons or domestic animals as have been exposed to a communicable disease, for a period of time equal to the longest usual incubation period of the disease, in such manner as to prevent effective contact with those not so exposed.

Modified Quarantine - A selective, partial limitation of freedom of movement of persons or domestic animals, commonly on the basis of known or presumed differences in susceptibility, but sometimes because of danger of disease transmission. It may be designed to meet a particular situation; examples are, exclusion of children from school or exemption of immune persons from provisions required of susceptible persons, prohibition of contacts from acting as food handlers, or restriction of military populations to the post or to quarters.

Surveillance - The practice of close supervision of contacts for purposes of quick recognition of infection or illness but without restricting their movements.

Segregation - The separation for special consideration, control, or observation of some part of a group of persons or of domestic animals from the others, to facilitate the control of a communicable disease. Removal of susceptible children to home of immune persons, or the establishment of a sanitary boundary to protect uninfected from infected portions of a population are examples.

The Incubation Period is the time interval between the infection of a susceptible person and the first appearance of the symptoms of the disease.

The Period of Communicability is the period during which the causative agent may be transferred directly or indirectly from the body of the infected person to that of another person.

A Carrier of a disease is a person who without showing the symptoms of the disease, harbors the specific pathogens and may disseminate them.

A Temporary Carrier is one who carries the pathogenic organisms for a short time.

A Chronic Carrier carries the pathogenic organism for an indefinitely long period.

An Antibody is a characteristic protective constituent of the blood and other fluids of the body which serves as a defense against disease producing agents.

A Serum is the clear yellowish fluid of the blood after coagulation of the fibrin and the blood corpuscles; it contains the antibodies.

A Vaccine is a suspension of dead or attenuated bacteria which, when injected into a body, produces active immunity.

A Toxoid is a neutralized toxin which is capable of producing active immunity when injected into the body.

A Toxin is any poisonous substance produced by a living organism.

Antitoxin is the antibody antagonistic to toxin, which is produced by an organism. There are specific antitoxins for specific toxins.

Immunity is a process, natural or acquired, by which the body resists disease.

Active Immunity is immuntiy produced by the body itself during a specific infection, or by inoculations of vaccines, toxoids or similar agents.

Passive Immunity is the immunity introduced into the body by injection of serums or similar agents which contain antibodies.

Natural Immunity is inherited immunity.

Herd Immunity is immunity which a group has by virtue of the character of its herd structure, and the herd's disposition in its environment.

Notification

Whenever a communicable disease occurs in a community, the case should be immediately reported to the local health department. The reporting of diseases is usually the duty of the family physician. But there are many instances when, due to various circumstances, the physician fails to report such cases. Then it becomes the duty of the parents, guardian, householder, attendent, or the intelligent and social-minded people of the community to report such cases. This function may devolve upon the school teachers who are in constant contact through the children with most families. Measures for the control of spread can only be instituted by the health authorities when they are informed of the existence of such diseases. It should never be forgotten that many children's diseases start as though they were common colds. Thus the signs of the common cold become an immediate signal of danger to the rest of the children. Sore throats, slight fever and flushing of face, droopiness, headaches, lack of appetite, emaciation, pallor, puffiness of face, swelling of neck, shortness of breath, eruptions, coughs, vomiting, nasal discharges, are all signs of danger which must be heeded, since they may also be the first signs of serious communicable diseases.

Reportable Diseases

A reportable disease may be defined as any disease or condition for which an official report is required. Reportable diseases usually include both communicable and non-communicable diseases and the content of the list varies from state to state. Two lists of reportable diseases are given below. One list contains the names of diseases which are reportable in ten or more states in the United States. The other list contains the names of diseases which are reportable in one to nine states.

Diseases reportable in ten or more states (1944): Actinomycosis, Anthrax, Arsenic poisoning, Botulism, Brass poisoning, Cancer, Carbon monoxide poisoning, Chancroid Chickenpox, Cholera, Compressed air poisoning, Conjunctivitis (acute infectious),Coccidioidomycosis,Dengue, Diarrhea (infantile), Diphtheria, Dysentery (amebic), Dysentery (bacillary), Encephalitis (infectious),Erysipelas, Favus, Food infections and poisoning, German measles,Glanders, Gonorrhea, Granuloma venereum (inguinale), Hemorrhagic jaundice, Hookworm, Impetigo contagiosa, Influenza, Lead poisoning, Leprosy, Lymphogranuloma venereum, Malaria, Measles, Meningococcic meningitis, Mercury poisoning, Mumps, Paratyphoid fever, Pellagra, Phosphorus poisoning, Plague, Pneumonia, Poliomyelitis, Psittacosis, Puerperal Infection, Rabies, Rat-bite fever, Relapsing fever, Rheumatic fever, Rocky Mountain spotted fever, Scarlet fever,Septic sore throat, Smallpox, Syphilis, Tetanus, Trachoma, Trichinosis, Tuberculosis (other than Pulmonary), Tuberculosis (pulmonary), Tularemia, Typhoid fever, Typhus fever, Undulant fever, Vincent's infection, Whooping cough, Wood alcohol poisoning, Yellow fever.

Diseases reportable in one or more states up to nine (1944): Ammonia poisoning, Aniline poisoning, Anthracosis, Ascariasis, Asbestosis, Benzine poisoning, Blisters or abrasions, Bronchitis, Bursitis, Cadmium poisoning, Carbon bisulphide poisoning , Carbon tetrachloride poisoning, Cataract of glass workers,Chlorine poisoning, Cholecystitis of typhoid origin, Chromic acid poisoning, Chronic ulceration, Colorado tick fever, Common cold, Conjunctivitis and retinitis due to electro- and oxy-acetylene welding or radiant energy, Cyanide poisoning, Dermatitis, Diabetes, Diarrhea, Dinitrobenzine poisoning, Drug addiction or habits, Echinococcus,Epilepsy, Epitheliomatous cancer or ulcer, Filariasis,Foot and mouth disease, Formaldehyde poisoning, Gasoline poisoning, Gastroenteritis, Heat prostration, Hepatitis (infectious), Hydrochloric acid poisoning, Hydrocyanic acid poisoning, Hydrofluoric acid poisoning, Hydrogen sulphide poisoning, Kerato-conjunctivitis (infectious),Lymphocytic choriomeningitis, Manganese poisoning, Meningitis, Mental deficiency or epilepsy, Metal fume poisoning, Methyl chloride poisoning, Milk sickness, Miner's diseases, Naphtha poisoning, Natural gas poisoning, Nickel carboxyl poisoning, Nitrous fume poisoning, Paragonimiasis,Pediculosis,Petroleum poisoning, Phosgene poisoning, Pneumoconiosis, Radium poisoning, Refrigerants poisoning, Rheumatic heart disease, Rickettsial diseases, Ringworm, Scabies, Schistosomiasis, Scurvy, Silicosis, Sporotrichosis, Sulphur dioxide poisoning,Sulphuric acid poisoning, Synovitis, Tetrachlormethane poisoning, Tetraethyl poisoning, Tick paralysis, Toluene poisoning, Turpentine poisoning, Veneral diseases, Yaws, Zinc poisoning.

The following classified outline of reportable diseases is generally satisfactory for the United States. It could be used with slight modification in any part of the country.

GROUP 1

Bacterial: Brucellosis (undulant Fever), Diphtheria, Meningococcal Meningitis and Meningococcemia, Pertussis, Rheumatic fever, Salmonellosis, Shigellosis, Tetanus, Tuberculosis (pulmonary), Tuberculosis (other types), Tularemia, Typhoid fever.

Virus: Infectious Encephalitis (primary virus mosquito-borne), Infectious Hepatitis, Poliomyelitis - Paralytic, Poliomyelitis - Non-Paralytic, Rabies in Man.

Rickettsial: Rocky Mountain Spotted Fever, Typhus fever (Endemic).

Protozoan: Amebiasis.

Parasitic: Hookworm, Trichinosis.

Venereal: Chancroid, Gonorrhea, Granuloma Inguinale, Lymphopathia Venereum, Ophthalmia Neonatorium, Syphilis.

Other: Cancer (Classified by type and site when possible).

GROUP 2 - ANY case of UNCOMMON DISEASE should be reported, such as: Anthrax, Botulism, Cholera, Dengue, Glanders, Leptospirosis (Weil's Disease), Leprosy, Malaria, Plague, Psittacosis, Q Fever, Rat-bite Fever, Relapsing Fever, Smallpox, Toxoplasmosis, Trachoma, Typhus Fever (Epidemic), Yellow Fever.

GROUP 3 - The following diseases should be reported only when they occur in UNUSUAL NUMBERS, since mass control measures are the only recommended procedures. These cases need not be reported individually by name: Chickenpox, Conjunctivitis - acute infectious (pink eye), Diarrhea of newborn (epidemic) - if 2 or more cases, Diseases resulting from occupation - if 2 or more cases, Food poisoning, German Measles, Impetigo Contagiosa, Influenza, Measles, Mumps, Ringworm of Scalp, Scabies, Scarlet Fever, Streptococcal Sore Throat.

GROUP 4 - Reportable only from Laboratory Examination.
Rabies in Animals.

Investigation

Investigation of a communicable disease can only proceed if notification be carried out. The importance of investigation by the local health department becomes evident when we consider the purpose of investigation. The purpose is: 1. To detect the source from which the disease has spread, 2. To discover other possible cases of the disease, 3. To prevent the spread of the disease from the discovered source, 4. To do whatever possible to minimize the effects of the disease in persons already infected.

Isolation:

Isolation has a distinct value in some communicable diseases and less value in others. The health authorities are the final judges as to how long, if any, isolation is required. Isolation in a hospital is the preferred method; first, because the patient will receive better and more expert care, secondly, because hospital isolation is much more effective than home isolation, and thirdly, because the rest of the family will not have to be quarantined for as long a time as had the patient remained at home. Isolation in a hospital may become a serious detriment to the sick person if the isolation technique in the hospital be not efficient. The period of isolation depends upon the disease. Some diseases remain communicable for longer periods than others. The period of isolation is as long as the disease remains communicable. In such diseases as diphtheria, pneumonia, scarlet fever, septic sore throat, tuberculosis, typhoid fever and whooping cough the termination of the period of communicability may be determined by laboratory methods and therefore each case may be individualized. For other diseases where laboratory determinations are not practicable, arbitrary periods of communicability are designated. For some diseases such as syphilis the practice of isolation is not practicable. The development of new effective drugs have a tendency to reduce the periods of isolation of such diseases for which they are effective by reducing the period of communicability.

The practice of isolation is carried out, not only for the purpose of preventing the spread of the disease from the sick to the well person but also to prevent the spread of other complicating illness to the individual who is already sick and whose body has been weakened as a result. Thus a child who has measles and contracts a cold, influenza, pneumonia or the like, has a greater chance of dying than when free of complication.

The periods of incubation and communicability of various diseases are outlined in Chart 1.

Quarantine.

Those people who have been in contact with a quarantinable communicable disease and may be in the process of developing it must be quarantined. It should be remembered that diseases do not immediately show themselves when a person is infected. It takes a certain number of days for the disease to develop in the body before the actual signs of the disease become manifest. The period of silent development is called the period of incubation. The period of quarantine depends

upon whether those who are to be quarantined remain in constant contact with the patient or whether they remain completely isolated from the patient. If they remain isolated from the patient they should be quarantined only for as long as the incubation period. If they remain in constant contact with the patient they must be quarantined for a period equal to the length of time that the patient may still communicate the disease plus the period of incubation.

In some epidemic diseases such as measles, influenza, chickenpox, and the like, quarantine does not seem to stop the course of the epidemic since this technique usually does not reach the large number of contacts who have been exposed outside the family. For such diseases it becomes more important to concentrate on the problem of protecting the younger age-group where the mortality is highest than in the routine enforcement of quarantine.

Placarding

Placarding the home where a communicable disease exists has limited value. It makes neighbors careful of homes where inmates are careless and uncooperative. It penalizes those who are admittedly recalcitrant to advice. Placarding is unnecessary for homes whose dwellers are socially minded and cooperative, but it is difficult to make discriminations. Health Departments should be reasonable with placarding practices. Such practice will be more effective when used with reasonableness than with blind stringency.

Disinfection

Disinfection of all the excretions of the patient is an important procedure, since many diseases are spread through the excretions. Therefore careful disposal of them must be carried out. After the patient is no more in the communicable stage, it is necessary to clean the room and all that is in it. This is best done with soap and water and sunshine. The attendant of the sick should disinfect her hands each time that she finishes her duties in the sick room. Outer clothing worn while attending the patient should be left in the sick room when the attendant's duties are completed. This clothing should be disinfected when being washed.

Disinfection of body excretions and disease-soiled linens is a very practical public health procedure. At least two hours contact should be provided for all disinfectants of body excretions. Body discharges should be collected in impervious vessels and immediately treated with disinfectants and covered to prevent access of insects. Where there is disease of the intestinal tract the feces and urine should be disinfected. Feces should be broken up with a stick to allow access of the disinfectant to all parts.

Disinfectants

1. Stock Solutions

Disinfectant	Percent	Amount per Gallon		How to make and Use Stock Solutions
		Ounces	Cupfuls	
Chlorinated lime	6	8	1-1/3	Select one of the five disinfectants opposite this space and mix the amount designated with one gallon of water. Make sure it is actually dissolved and does not settle. This is the stock solution ready for use. Put on POISON label and keep tightly corked. Add at least an equal amount of the stock solution to the feces and urine to be disinfected; break up all masses and let stand two hours.
Formalin	10	14	2-1/3	
Cresol or Cresylic Acid	2	2-1/3	1/3	
Liquor cresolis composition	3	4	2/3	
Crude carbolic acid	6	8	1-1/3	

2. Lime and hot water: Do not make stock solution. Pour in enough hot water to cover the mass of feces, then add about one-fourth the entire bulk of unslacked lime. A large cup of lime will usually suffice for an average stool. The heat generated by the hydration of lime helps kill germs. Let stand till cool.

3. When other agents are not available, a bucket of boiling water (about 1 gal.) added to a stool which is then covered and allowed to stand until cool, will destroy practically all bacteria with the exception of spore-formers such as the anthrax bacillus.

4. For disinfection of the hands use soap and warm water. Alcohol (70%) may be used for rinsing the hands after thorough washing.

5. Bed linens, clothing, etc. (non-wool) should be boiled. Woolens, mattresses and bulky materials should be exposed to the direct rays of the sun for a day.

6. All dishes and utensils from the sick room should be boiled.

7. All remnants of food should be burned.

Carriers

The control of carriers of diseases has always been a difficult problem. These people are dangerous because they may spread diseases to other people but may never be detected as the source, and because of the many unsolved factors related to the handling of them. It is the duty of the health department to find as many carriers as possible and to do the best that is known in handling them. For instance a carrier of typhoid germs may be working in a dairy. The individual is not sick but in handling the milk he may eventually contaminate it. The result is an epidemic of typhoid fever. The health department may trace the disease to this individual. In spite of much treatment this individual may persist in carrying the germs. Such an individual can at least be under the supervision of the health department. He can be forbidden to do such type of work as may be instrumental in spreading diseases.

Increase of Resistance of Individuals in the Community Against Specific Diseases

There are some communicable diseases the control of which is greatly aided by inoculation with vaccines and toxoids. There is a two-fold process in the body which fights disease. This process is called resistance and its two-fold character is made up of its specific and non-specific fighting forces. The interdependent relation between these two forces is fundamental in the science of immunity. Specific resistance means acquired bodily resistance against specific pathogens such as cause smallpox or typhoid or any other particular disease. Non-specific resistance means bodily resistance against disease producing germs without apparently being immunized specifically against those pathogens. Specific resistance is developed in the body by its struggle against a specific pathogens. It could not develop without being in some way stimulated by the particular germ or the nocuous substances from that particular germ. During the process of mobilization and development of the body defense against other pathogens, it also, in many instances, may build a defense against other pathogens, or may naturally have had such a defense. This latter defense is non-specific resistance. Thus in the course of the development of specific resistance, there may also be a certain amount of non-specific resistance developed. Non-specific resistance may also be related to nutrition, environment and heredity. These latter factors build general non-specific resistance by supplying the raw material and energy, and stimulate the dynamic processes of defense. The factors which aid in developing the non-specific resistance potential may also develop the vigor of the specific resistance mechanism.

Periods of Incubation and Communicability

	Incubation Period	Period of Communicability
Actinomycosis	Undetermined and variable	As long as open lesions give off the germ.
Amebiasis	2 days to several months: 3 to 4 weeks usually	Until the ameba is no longer found in the stool after repeated examination
Anthrax	Within 7 days. Usually less than 4 days	Until sores have healed. But infected hair and hides may harbor the germs for many months unless disinfected
Argentinian hemorrhagic fever	10 to 14 days usually	Probably not transmitted directly by man
Ascariasis	2 months after infection	As long as mature female worms live in intestines
Aspergillosis	A few days to weeks	Not directly transmitted by man
Bartonellosis	Oroya fever stage 16 to 22 days. Verruga peruana 30 to 60 days	Unknown: Probably as long as germs are present in red blood cells
Blastomycosis	Probably a few weeks or less	Not transmitted directly by man
Bolivian hemorrhagic fever	10 to 14 days usually	Possibly by direct transmission by man
Boutonneuse fever	5 to 7 days	Not directly transmitted by man
Candidiasis	2 to 5 days	As long as lesion remains
Cat Scratch Fever	7 to 14 days, as short as 2 days	Not directly transmitted by man
Chancroid	1 to 10 days, usually 3 to 5 days	As long as organism persists in lesion
Clonorchiasis	Undetermined	As long as man passes eggs in stool
Chickenpox (Varicella)	2 to 3 weeks	Until about 6 days after the first appearance
Cholera	1 to 5 days, usually 3 days	Until the organism is absent from stool. Usually 7 to 14 days
Choriomeningitis, lymphocytic	Probably 8 to 13 days until systemic symptoms: 15 to 21 days until meningeal symptoms	No evidence of person to person transmission
Chromoblastomycosis	Unknown, weeks or months	Not directly transmitted by man
Coccidioidomycosis	1 to 3 weeks for valley fever: Undetermined for granuloma form	As long as open lesions persist. Man to man spread is not important
Colorado tick fever	4 to 5 days	Not directly transmitted by man
Common cold	Probably 12 to 72 hours	Probably no longer than 1 week
Conjunctivitis, acute bacterial	Irregular, usually 36 to 48 hours	Until discharges cease from infected mucous membrane
Conjunctivitis, inclusion	5 to 7 days, occasionally 10-12 days	As long as genital infection persists.
Crimean hemorrhagic fever	7 to 12 days	Not directly transmitted by man - tick-borne
Crytococcosis	Unknown	Not transmitted directly by man
Dengue fever	3 to 15 days, usually 5 to 6 days	From day before onset to 5th day of disease
Diarrhea, infant, Epidemic	Variable, usually 1 to 4 days	As long as symptoms exist
Diphtheria	2 to 5 days, occasionally longer	2 to 4 weeks, depending on how long the germ is found in nose or throat
Dracontiasis	8 to 14 months	Not transmitted directly by man
Dysentery, Bacillary (Shigellosis)	1 to 7 days, usually less than 4 days	Until organism is no longer present in stool
Diphyllobothriasis	3 to 6 weeks	Not transmitted directly by man
Echinococcosis	Variable, from months to years	Not transmitted directly by man
Encephalitis, E. Equine	5 to 15 days	Not directly transmitted by man. Mosquito-borne
Encephalitis, W. Equine	5 to 15 days	Not directly transmitted by man. Mosquito-borne
Encephalitis, St. Louis	5 to 15 days	Not directly transmitted by man. Mosquito-borne

	Incubation Period	Period of Communicability
Encephalitis, Japanese B.	5 to 15 days	Not directly transmitted by man. Mosquito-borne
Encephalitis, Murray Valley	5 to 15 days	Not directly transmitted by man. Mosquito-borne
Encephalitis, Russian	7 to 14 days	Not directly transmitted by man. Tick-borne
Encephalitis, diphasic	7 to 14 days	Not directly transmitted by man. Tick-borne
Encephalitis, louping ill	7 to 14 days	Not directly transmitted by man. Tick-borne
Encephalitis, Powassan	7 to 14 days	Not directly transmitted by man. Tick-borne
Enterobiasis	3 to 6 weeks	2 to 8 weeks unless treated or reinfected
Erysipelas	2 to 10 days	Until local lesions and purulent discharges disappear
Fasciolopsiasis	About 3 months	As long as man passes eggs in stool
Favus	Unknown	Until skin and scalp lesions are healed as shown by gross, Microscopic, and ultraviolet examination
Foot and mouth disease	In animals: 18 hours to 3 weeks, usually 3 to 6 days	At least until skin and mucous membrane lesions heal
Filariasis	1 month to several years	From about 9 months after infection until the embryo microfilaria are no longer present in blood
Food infections (Salmonellosis)	6 to 48 hours, usually about 24 hours	Throughout illness
Food Poisoning	Staphylococcic: ½ hour to 8 hours, usually 2 to 4 hours. Botulinus: Average 24 hours	None
German Measles (Rubella)	14 to 21 days, usually 16 days	From onset of catarrhal symptoms for at least 4 days and not more than 7 days
Glanders	Usually 1 to 5 days	Until organisms disappear from discharges or lesions are healed
Gonorrhea	1 to 8 days, usually 3 to 5 days	As long as organism is found in discharge
Granuloma Inguinale	From a few days to 3 months	As long as there are open lesions
Haverhill fever (rat bite fever)	2 to 10 days	Does not spread from man to man
Hemorrhagic fevers (S.E. Asia)	Unknown	No evidence of direct transmission
Hemorrhagic Jaundice (Leptospirosis)	4 to 19 days, usually 9 to 10 days	Rarely spreads from man to man. Organisms are found in urine for weeks or months after convalescence
Hepatitis, Infectious	15 to 50 days, usually 25 days	Unknown
Herpangina	3 to 5 days	During acute stages and perhaps longer
Histoplasmosis	5 to 18 days, usually 10 days	Not directly transmitted by man
Hookworm (Ancylostomiasis)	2 to 3 weeks in meassive infections to many months, usually 7 to 10 weeks	As long as adult worms are present in intestinal tract
Impetigo Contagiosa	Within 5 days	While lesions containing pus remain unhealed
Influenza	1 to 3 days	Until patient appears completely well
Kerato-Conjunctivitis, Infectious	Probably about 5 days	At least during the acute stage
Kyasanur forest disease	3 to 8 days usually	Not directly transmitted by man
Leishmaniasis (cutaneous)	From a few days to many months	As long as open lesions are present
Leishmaniasis (visceral, Kala Azar)	2 to 4 months usually, as short as 10 days and as long as 24 months	Not directly transmitted from man to man
Leprosy	Prolonged, probably 1 to several years	Until all lesions are healed and are microscopically negative
Listeriosis	Unknown, probably 4 days to 3 weeks	Rarely communicable by man, except congenitally
Loiasis	4 months to several years	Not transmitted directly by man

	Incubation Period	Period of Communicability
Lymphogranuloma Venereum	7 to 12 days usually, ranges 5 days to several months	As long as there is an open lesion
Malaria	14 days for tertian type	As long as the sexual form of the organism is present in the blood for mosquito transmission
Measles (Rubeola)	About 10 days, as long as 21 days	Until 1 week after the first appearance of the rash
Meningitis, Aseptic	Variable, depending on virus	Variable depending on virus
Meningococcus Meningitis	2 to 10 days, usually 7 days	Usually 2 weeks, but until the organism disappears from oral and nasal discharges
Mononucleosis, Infectious	2 to 6 weeks	Undetermined
Mumps	12 to 26 days, usually 18 days	Until the swelling disappears
Mycetoma	Usually months	Not transmitted directly by man
Nocardiosas	Unknown	Not transmitted directly by man
N. Asian tick typhus	2 to 7 days	Not transmitted directly by man
Omsk hemorrhagic fever	3 to 8 days usually	Not directly transmitted by man
Onchocerciasis	3 to 4 months	Not transmitted directly by man
Paracoccidioidal granuloma	Probably a few weeks or less	Probably not transmitted directly by man
Paragonimiasis	Probably about 6 weeks	Not transmitted directly by man
Paratyphoid fever	1 to 10 days	Until the organism is no longer present in discharges
Pediculosis	Lice hatch in a week and mature in 2 weeks	As long as lice and nits are present
Pertussis	Usually 7 days, seldom more than 10 days	Until about 3 weeks after whoop appears. Depending on how long the germs are present in oral discharge
Pinta	7 to 20 days	Unknown, probably as long as skin lesions exist
Plague	Usually 3 to 6 days, occasionally longer	Pneumonic type, during acute symptoms: Bubonic type not communicable
Pleurodynia	3 to 5 days	Apparently during acute stage
Pneumonia, Pneumococcus	Probably 1 to 3 days	Unknown, probably until oral and nasal discharges no longer carry the germ
Pneumonia, (other bacteria)	Variable, usually 1 to 3 days	Unknown, probably until oral and nasal discharges no longer carry the germ
Pneumonia, viral	Variable, accompanying various viral diseases	Variable, depending on viral disease
Pneumonia, (PPLO) mycoplasmal	Probably 7 to 21 days, usually 12 days	Undetermined, 10 days or less
Poliomyelitis	7 to 14 days or longer	Undetermined, probably from latter part of incubation period to the 1st or 2nd week of the disease
Psittacosis	6 to 15 days	During acute illness especially when coughing
Q fever	Probably 14 to 26 days	Not spread from man to man
Queensland tick fever	7 to 10 days	Not spread directly by man
Rabies	2 to 6 weeks, as long as 6 months or more	In dog: 8 to 10 days before onset of symptoms and during course of disease
Rat-bite fever (Sodoku) (Spirillum minus)	Usually 1 to 3 weeks	Does not spread from man to man
Relapsing fever	Louse Borne. Up to 12 days. Average is 7 days Tick Borne. 2 to 12 days: usually 3 to 6 days	Depends on presence of lice. Not communicable from man to man
Rheumatic fever	Unknown	Not communicable
Rickettsialpox	Undetermined	Person to person spread not known

	Incubation Period	Period of Communicability
Ringworm	Undetermined	As long as organisms are present in lesion
Rocky Mountain Spotted Fever	3 to 10 days	Not communicable from man to man
Sandfly fever	3 to 4 days usually	Not directly transmitted by man; Phlebotomus fly-borne
Scabies	Several days or even weeks	Until mites and eggs are destroyed
Scarlet fever	2 to 7 days, usually 3 to 4 days	In uncomplicated cases, until a few days after clinical recovery. In complicated cases resulting in purulent discharges, communicability is possible for long periods.
Schistosomiasis	1 to 3 months after infection before eggs are found in stool or urine	As long as eggs from case find way to sewage polluted water where snails abound
Scrub typhus (mite-borne)	10 to 12 days usually, 6 to 21 days	Not directly transmitted by man
Smallpox	7 to 16 days: Usually 12 days	Until scales and crusts disappear
Sporotrichosis	3 weeks to 3 months	Rarely spreads from person to person
Streptococcal sore throat	1 to 3 days	Until germs disappear from throat
Strongyloidiasis	Indefinite	As long as worms remain in intestines
Syphilis	About 3 weeks: May be 10 days to 6 weeks or longer	During primary and secondary stages; up to 5 years if not treated adequately
Taeniasis	8 to 10 weeks	Not transmitted directly by man
Tetanus	4 days to 3 weeks	Not infectious
Toxoplasmosis	Undetermined	Person to person spread not known: Possibly communicable as long as sputum remains positive
Trachoma	5 to 12 days	During persistence of lesion or discharge therefrom
Trichomoniasis	4 to 20 days, average 7 days	During period of infection
Trichinosis	6 or 7 days after ingestion of meat. Gastrointestinal symptoms may appear in 24 hours in heavy infection	Not communicable from man to man
Trichuriasis (Whipworm)	About 3 months	As long as eggs are passed in feces
Trypanosomiasis, African	2 to 3 weeks, as short as 7 days	Not transmitted directly by man
Trypanosomiasis, American	About 7 to 14 days	Not communicable from man to man
Tuberculosis	Variable	As long as patient discharges germs, or cow's milk is infected
Tularenia	1 to 10 days, usually 3 to 4 days	No record of spread from man to man
Typhoid fever	7 to 14 days usually, maybe 3 to 38 days	Until no germs are found in excreta after successive specimens are taken
Typhus fever (louse-borne)	6 to 14 days, usually 12 days	Not directly transmitted by man
Typhus fever (flea-borne)	6 to 14 days, usually 12 days	Not directly transmitted by man
Viral fevers Bunyamwera Bwamba Chikungunya Mayaro O'nyong-nyong Rift Valley Venezuelan Equine West Nile Group C.	3 to 12 days	Not directly transmitted by man. Mostly mosquito-borne
Visceral larva migrans	Probably weeks or months	Not directly transmitted by man
Vulvovaginitis in children	Variable	As long as germs are present in discharges
Yaws	3½ weeks to 3 months	As long as discharges issue from open lesions
Yellow fever	3 to 6 days	First 3 or 4 days of fever, mosquito-borne

Since resistance as induced by vaccines and toxoids has indeed been a miracle in public health. The earliest disease to be fought by this method was small pox (1774). Later came anthrax (1881), rabies (1885), typhoid (1900), diphtheria (1912), tuberculosis-BCG (1924), Scarlet fever (1924), rocky mountain spotted fever (1925), whooping cough (1933), tetanus (1933), plague (1935), influenza (1936), Yellow fever (1938), typhus (1939), cholera (1942), tularemia (1944), Russian Far East Encephalitis (1944), Poliomyelitis (1954), and measles (1962). At present, vaccines for rubella and mumps are about ready for mass application.

Artificial immunization and sanitation are the two bulwarks that public health organizations have used in their fight against epidemic diseases. There are periods of apathy among the population toward the precaution of vaccination. These periods always occur in times when certain preventable diseases are long absent from the community. But when a few cases break out there begins a clamor for vaccination, then too late to be most effective. Such circumstances usually occur in relation to smallpox, typhoid fever and diphtheria. Vaccination during a typhoid epidemic is usually of limited value so far as controlling immediate ravages of the epidemic is concerned. This is due to the fact that it takes 5 to 6 weeks for the typhoid vaccination to become effective, whereas the incubation period of typhoid fever is 7 to 14 days. Thus during the prolonged period during which the immunity is being built up the epidemic has time to run wild. The time to vaccinate is before an epidemic breaks out.

In diphtheria we meet the same problem. This disease has even a shorter incubation period (2 to 5 days) whereas the period of effectiveness of the initial toxoid immunization begins 6 weeks to 3 months after the inoculation is made. Thus in 45 to 90 days untold ravages may occur. The time to administer the initial toxoid injection is several months after birth.

Active And Passive Immunity.

Active immunity is that type of protection against disease which the body itself builds up. This is illustrated by the protection which the body developes after introduction of smallpox or typhoid vaccine or diphtheria toxoid into the body. These substances stimulate the body to build up an army of defense against the particular disease. This defense consists of certain materials dissolved in the body fluid, which have the power to fight against diseases. These materials are called antibodies. Because the body itself takes an active part in building up these defense materials, the condition is called active immunity and the procedure is called "active immunization".

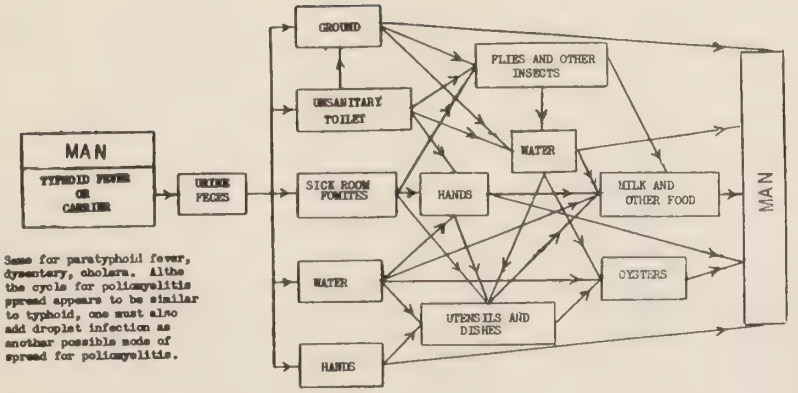
Passive immunity is that type of protection against disease which the body receives from the outside and plays no part itself in building up. This is illustrated by the injection into the body of serums or antitoxins for protection against such diseases as diphtheria, tetanus and pneumonia. In simple terms, a serum may be defined as the fluid portion of the blood (i. e., minus the red and white corpuscles and clotting substances) which contains, among other things, the antibodies. There are many kinds of antibodies such as antitoxin, agglutinin, precipitin, lysin, and opsonin. The antitoxin antibody neutralizes the poisons or toxins produced by pathogens. The other antibodies act in various other ways in their battle against pathogens. The serum, containing antibodies, which is injected into a sick individual to fight a particular disease is obtained from other immunized humans or animals where it had been produced. Since the sick person into whom this protective serum is injected took no active part in producing these protective substances, the condition is called passive immunity and the procedure is called "passive immunization".

Each of these two types of immunization serve a particular function. Active immunization protects the body against the invasion of disease germs. Passive immunization is an emergency measure to fight off a disease already attacking the body. Thus diphtheria toxoid is injected as a preventive into a well body for the purpose of building up an active defense against this disease before the attack. Diphtheria antitoxin is injected as a therapeutic into a body already sick with diphtheria to bolster the body's defense against the disease. Active immunity lasts over in an extended period of time. Passive immunity is short-lived.

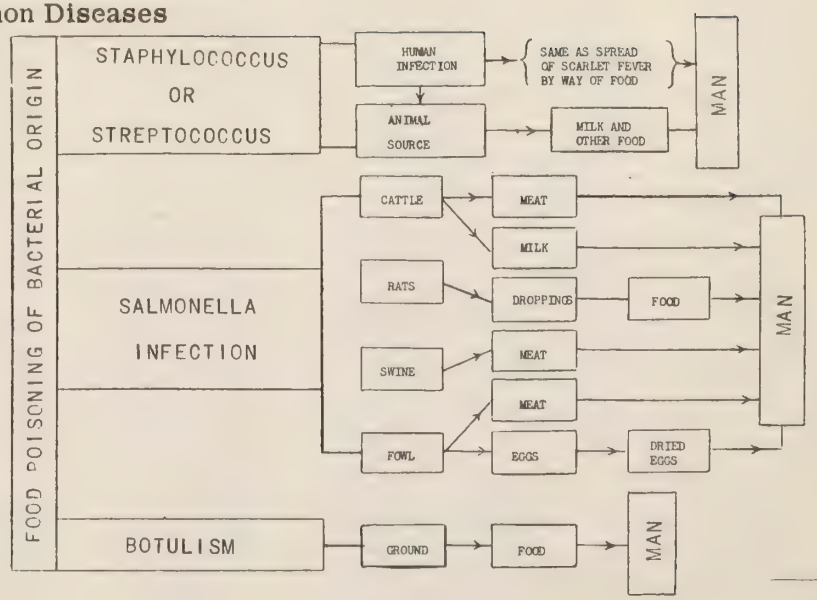
Active immunity can be differentiated into 2 types: (1) Acquired active immunity, specific and non-specific, resulting from an actual attack of a particular disease or an immunizing agent, such as a vaccine or toxiod. (2) Innate or genetic immunity which is inherited. Man or other species of animals inherit resistance against certain types of parasites or poisons. Herd immunity is that which results from the peculiar circumstances of the environment, habits, customs, traditions

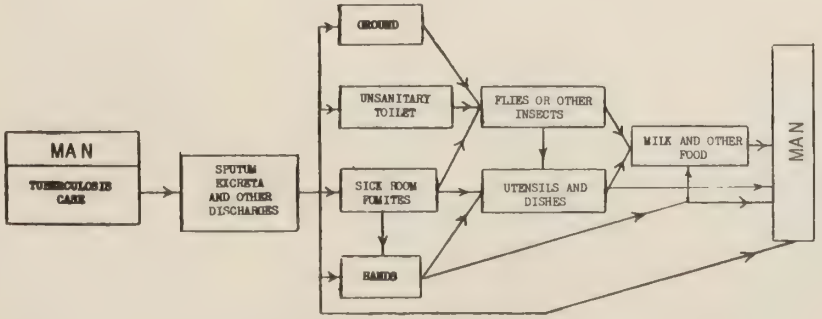
Chart 2

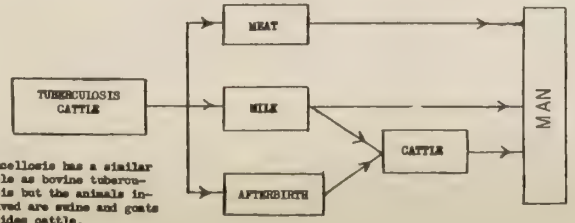
Diagrammatic Illustration of Spread of Various Common Diseases



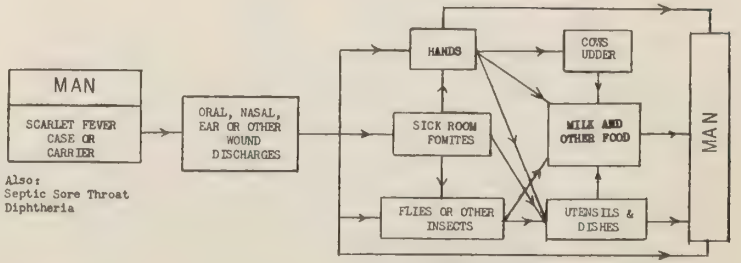
Same for paratyphoid fever, dysentery, cholera. Althe the cycle for poliomyelitis spread appears to be similar to typhoid, one must also add droplet infection as another possible mode of spread for poliomyelitis.



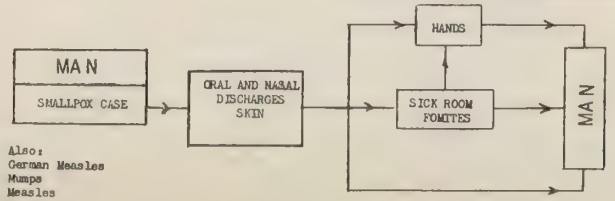




Brucellosis has a similar cycle as bovine tuberculosis but the animals involved are swine and goats besides cattle.

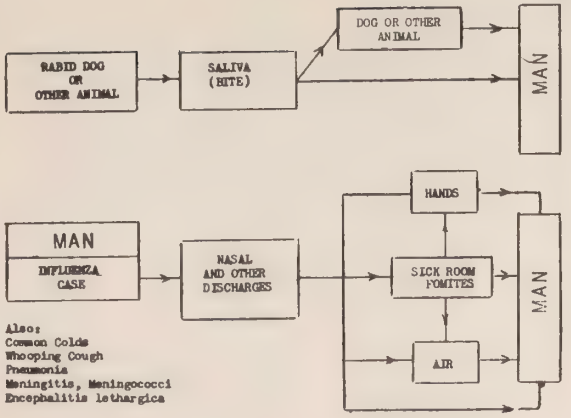


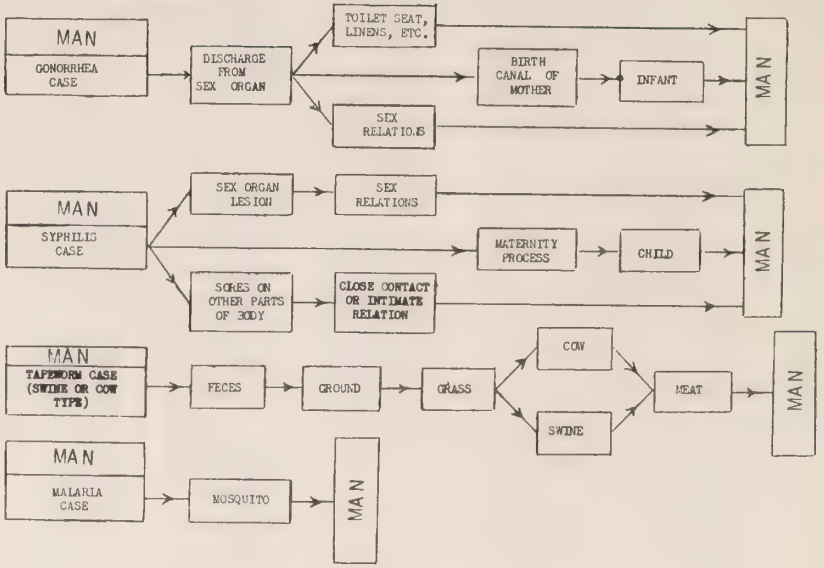
Also:
Septic Sore Throat
Diphtheria

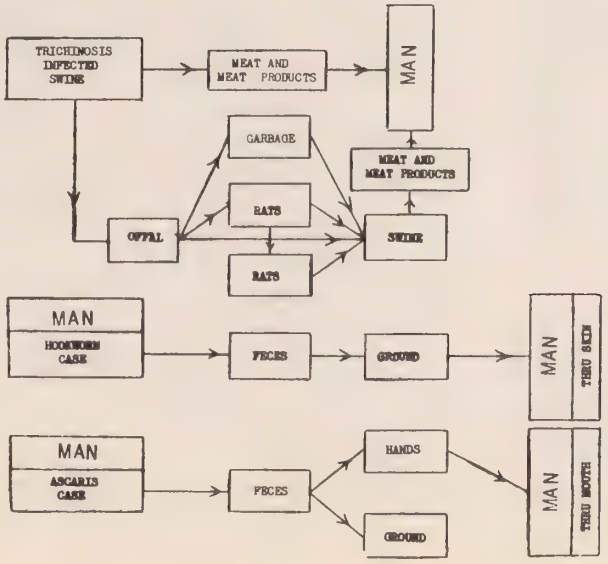


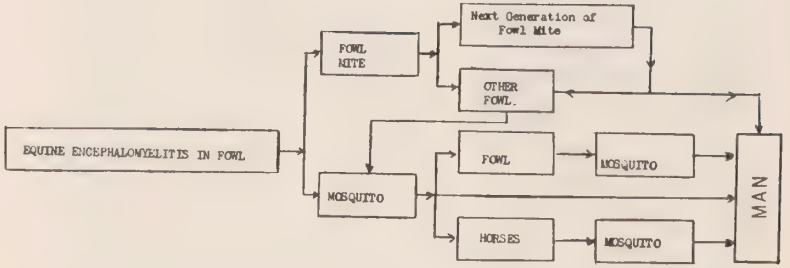
Also:
German Measles
Mumps
Measles
Chickenpox

Chart 3
Diagrammatic Illustration of Spread of Various Common Diseases









and other social conditions under which a group of people has lived for a relatively long period of time. It is the immunity resulting from the character of the ecology. Such environmental hygiene which becomes part of a community's way of life is part of the herd immunity of that group.

General Measures For Control of Various Communicable Diseases.

Aside from specific measures taken to prevent spread of communicable diseases, certain general measures must necessarily be instituted. These measures deal with controlling the agents which carry the disease. The three most important non-living agents or vehicles of transmission which carry diseases are water, food, and human excreta. Therefore, water must be supervised against contamination, food supplies and especially milk, shellfish and meat, must be under scrupulous supervision with special attention to the encouragement of pasteurization of milk, and the disposal of excreta must be placed under sanitary regulations.

The most important living agents or vectors which spread disease, excluding human cases and carriers, are mosquitoes, flies, rats, fleas, lice and ticks. Special efforts must be made to control their growth and development if such diseases as malaria, plague, typhus fever, spotted fever, smallpox and cholera, etc., are to be prevented from becoming epidemic or even pandemic.

Because of the peculiarities or lack of epidemiological knowledge concerning some communicable diseases, no definite general measures of control can be recommended. The following recommendations are those of the American Public Health Association (1950) with some modifications and some additions. It is understood that all control measures require certain adjuncts of medical practice involving therapeutic measures. Since the information contained herein is directed mainly toward sanitarians, the therapeutic measures are only mentioned in those instances where treatment is of special importance in the general practices of control.

Anthrax.

1. Animals ill with disease presumably anthrax should be isolated immediately and put in care of a veterinarian. Animals proved to have the disease should be killed and promptly destroyed preferably by incineration.
2. Immunization of exposed animals should be put under direction of the United States Department of Agriculture, or State livestock sanitary authority.
3. Post-morten examination of animals should be made only by a veterinarian or in the presence of one.
4. Milk from an infected animal should not be used.
5. Control and disinfection of effluents and trade wastes and of areas of land contaminated by such effluents and wastes from factories or premises where spore-infected hides or other infected hide and hair products are known to have been used in the manufacture of articles.
6. Concurrent disinfection of the discharges from lesions and articles soiled therewith. Spores can be killed only by special measures such as steam under pressure or prolonged heat above 140°C. (284°F.) or burning.
7. A physician should be employed by every company handling raw hides, or such companies should operate under the direct supervision of a medical representative of the health department.
8. Every employee handling raw hides, hair or bristles who has an abrasion of the skin should immediately report to a physician.
9. Special instruction should be given to all employees handling raw hides about the necessity of personal cleanliness.
10. Tanneries and woolen mills should be provided with proper ventilating apparatus so that dust is promptly removed before reaching the respiratory tract of human beings.
11. Disinfection of hair, wool and bristles from sources known or suspected to be infected, before they are used or sorted, should be obligatory.
12. The sale of hide from an animal infected with anthrax should be prohibited. A violation of this regulation should be immediately reported to the appropriate State livestock sanitary authority by telegram, stating the time, place and purchaser to whom the hide was sold. The report should also be sent to the person purchasing the hide. Carcasses should be disposed of under the supervision of the appropriate livestock sanitary authority. Imported hides are subject to regulations administered by the United States Bureau of Animal Industry. In the event that infection is introduced, the State livestock sanitary authorities should have jurisdiction over infected animals and

the local or State health authorities should have jurisdiction over infected persons.

Ascariasis.

1. Provision of adequate facilities for proper fecal disposal and elimination of soil contamination in areas immediately adjacent to the home, particularly in play areas of children.
2. In rural sections, privies should be so constructed as to obviate dissemination of ascarid ova through overflow, drainage, and other factors.
3. Education of all members of the family, particularly children, to use toilet facilities.
4. Encouragement of satisfactory hygienic habits on the part of children in particular, especially the practice of washing the hands before handling food and after defecating.

Bartonellosis.

Same general measures as for Sandfly Fever.

Boutonneuse Fever (Mediterranean Fever)

1. In areas where ticks are known to be infected, a systematic effort to reduce their prevalence would appear indicated.
2. Restrict movement of dogs from areas where the disease is endemic.
3. Pest control measures in households of cases.

Chancroid.

Same general measures as for gonorrhea except that prophylactic use of silver nitrate solution or other agent in the eyes of the new-born does not apply here.

Chicken pox (Varicella)

1. Children should be excluded from school for period of communicability. Articles soiled by nose and throat discharges and from lesions should be disinfected.
2. The possibility of cases being smallpox should be kept in mind.

Cholera.

1. Sanitary disposal of human feces.
2. Protection of water supplies against human fecal contamination.
3. Boiling of milk or pasteurization of milk and dairy products.
4. Sanitary supervision of processing, preparation and serving of food in public places.
5. Control of house fly by screening and use of insecticides with residual effect.
6. Education of the public in habits of personal cleanliness especially washing hands before eating and after defecation.
7. Isolation of patient in hospital or screened room during the communicable period.
8. Prompt and thorough disinfection of feces and vomitus. Articles used by and in connection with the patient must be disinfected. Rigid personal protection of attendents by scrupulous cleanliness, disinfection of hands each time after handling the patients or touching articles contaminated by feces, the avoidance of eating or drinking anything in or from the sick room and the prohibition of those attendant on the patient from entering the kitchen. Terminal disinfection of the sick room is mandatory.
9. Contacts must be quarantined for 5 days from last exposure or longer if feces contain cholera vibrio.
10. Contacts should be immunized.

Epidemic measures:

1. Immediate provision for administration of cholera vaccine to exposed population groups.
2. The identification and isolation of carriers if possible.
3. Boiling of water if used for drinking, toilet purposes or washing dishes or food containers, unless the water supply is adequately protected and treated.
4. Careful supervision of food and drink against contamination by handling or by flies or other insects.

5. Control of fly breeding by use of insecticides with residual effect and the screening of kitchens and eating places.
6. Inspection service for early detection and isolation of infected persons and control of carriers. Concurrent and terminal disinfection.
7. Each government should notify adjacent governments and the World Health Organization.
8. All precautionary measures should be invoked on departure of vessels and aircraft from infected areas.
9. All precautionary measures should be invoked on arrival of vessels and aircraft.
10. Merchandise and baggage that may have been contaminated must be disinfected.
11. Land traffic must be controlled in and out of infected area.

Coccidioidomycosis (Coccidioidal granuloma, valley fever)

1. Local measures for dust control advisable, but of limited value.
2. Laboratory workers should exercise particular care in handling cultures of the infecting microorganism and dried material which may contain its spores.
3. Burial of infected animals.
4. Post-mortem inspection of all animal carcasses to be used for human food.
5. Disinfection of contaminated dressings and sputum from cases.

Common Cold.

1. Education in the niceties of personal hygiene and disposal of nose and mouth secretions.

Conjunctivities, Acute Infectious (of the New Born not Including Trachoma).

1. Use of silver nitrate solution or equally effective chemoprophylactic or antibiotic agent in the eyes of the new born; antepartum treatment of mother if gonorrhea or other infection be suspected.
2. Education as to personal cleanliness and as to the danger of the use of common towels and toilet articles.
3. Carrying out of the measures indicated in methods for control of gonorrhea.
4. Disinfection of conjunctival discharge and articles soiled therewith.
5. If in maternity hospital, isolation must be strictly observed; otherwise no isolation, provided the patient is under adequate medical supervision.

Dengue.

1. Measures directed toward elimination of the vector mosquitoes and their breeding places. Screening of rooms. Use of repellents.
2. Patient should be kept in screened room or quarters treated with insecticide with residual effect, for 5 days after onset.
3. Enforcement of provisions of international convention designed to stop mosquito transfer by public conveyance from areas of prevalence to areas free from the disease.
4. Telegraphic notification of foci.

Diarrhea of the New Born, Epidemic.

1. The complete physical separation of the maternity service from all medical and surgical services in the hospital.
2. The establishment of completely equipped physical facilities in small units for the labor, delivery, and after care of uninfected maternity patients, each such unit to be served by a nursery for the care of uninfected new born infants.
3. The establishment of completely equipped physical facility units for the labor, delivery, and after care of maternity patients with any form of infection, such unit to be served by a cubicled nursery for the care of babies infected with diarrhea of the new born or other communicable infections.
4. The establishment of a special nursery for the care of uninfected premature babies and another for the special care of infected premature babies.
5. The organization of a maternity service nursing staff with duties limited to the care of

maternity patients and their babies. Part of this staff should be assigned to care of uninfected mothers and babies only and another part to the care of maternity patients and their babies with any form on infection.

6. The establishment of a formula room specifically reserved for preparation of formulas for new born infants, apart from any diet kitchen, scullery, pantry or place of food storage in the hospital.

7. The adoption of the principles of aseptic nursing care in the handling of all maternity patients and their babies in all phases of obstetrical and pediatric care. Hospital practice of keeping baby in same room with mother reduces risk of diarrheal infections.

8. The collection, storage, and laundering separately of all linens, diapers, and articles of clothing which may come in contact with the new born.

9. Limitation of visiting hours. These are not to be permitted when new born infants are being fed or nursed by the mothers. Visitors should be kept to a minimum, and children under 14 should be excluded. Special facilities should be provided to protect the new born against possible introduction of infection into the nursery during religious rituals.

10. Immediate removal of infected and suspected babies from nursery to isolation quarters.

11. Disinfection of all discharges and articles soiled therewith during course and at termination of illness.

Epidemic measures.

1. Closure of contaminated nursery of the maternity hospital to new admissions, and suspension of maternity service unless adequate personnel and satisfactory facilities including uninfected nurseries are available to care for new admissions. All exposed babies in the nursery should be cared for by separate medical and nursing personnel skilled in communicable disease technics. Babies should be observed for at least two weeks following the removal of the last case from the contaminated nursery. The maternity service may be resumed after discharging of all contact babies and mothers.

2. Survey the hospital for sanitary hazard.

3. Examination of method of preparation of formulae for babies to determine sterility of technic, investigation of refrigeration, bacteriological examination of solutions and sugars used in preparation of formulae and their storage. Bacteriological examination of rubber nipples and bottle caps.

4. Inquiry into the technique of aseptic nursing of infants, of changing of their diapers and of laundering infants' diapers and other clothing.

5. Bacteriological examination of feces of all sick and exposed babies, mother, and maternity service personnel.

6. Examination of mothers and of maternity service personnel for early signs of illness.

7. Follow-up examination of all who were discharged in the two week period before the onset of the initial case in the hospital.

Diphtheria.

1. All children should be immunized against diphtheria and later with booster immunizations. This should be intensified in presence of an epidemic.

2. Older children and adults especially exposed, including teachers, nurses and physicians found to be Schick-positive, should be actively immunized.

3. Cases should be isolated and intimate child contacts should be quarantined.

4. Pasteurization of milk supply.

5. Educational measures to inform the public and particularly the parents of little children of the advantages of toxoid immunization in infancy.

6. Concurrent and terminal disinfection should be made.

Dysentery, Amebic.

1. Sanitary disposal of human feces.

2. Protection of potable water supplies against fecal contamination, and boiling drinking water where necessary. Chlorination of water supplies as generally used has been found inadequate for the destruction of cysts. Sand filtration of water removes nearly all cysts.

3. Supervision of the general cleanliness, personal health and sanitary practices of persons

preparing and serving food in public eating places, especially moist foods eaten raw. The routine examination of food-handlers to eliminate carriers from such occupations is of little or not practical value.

4. Education in personal cleanliness, particularly washing hands with soap and water after evacuation of the bowels and before eating.

5. Control of fly breeding and protection of foods against fly contamination by screening and the appropriate use of insecticides with residual effect.

6. Avoidance of cross-connections between public and private auxiliary water supplies and of back-flow connections in plumbing systems.

7. Instruction of convalescent and chronic carriers in personal hygiene, particularly as to sanitary disposal of fecal waste, and hand washing after use of toilet and before preparing or eating food.

Epidemic measures:

1. Intensification of sanitary supervision of water supplies and of food supplies and their processing and serving.

2. Educational emphasis upon personal hygiene in respect to disposal of feces and hand washing after defecation and before eating.

Dysentery, Bacillary.

1. Protection and purification of public water supplies, including prevention of subsequent contamination. Avoidance of cross-connections and back-flow connections in plumbing systems.

2. Pasteurization of public milk supplies; use of boiled milk for infant feeding.

3. Sanitary disposal of human excreta.

4. Supervision of preparation and handling of all foods, particularly those which are moist and eaten raw.

5. Hand washing by food-handlers in particular, following use of toilet and before handling or eating food.

6. Fly control and protection of foods against fly contamination by screening and appropriate use of insecticides with residual effect.

7. Persons known to be infected and their attendants should be excluded from handling the family food supply if possible.

8. The exercise of rigid precautions in known cases of bacillary dysentery is requisite but is inadequate as a safeguard against the risk of infection from unrecognized sources. The reduction of high infant mortality rates is dependent upon prevention of diarrhea and enteritis. Infant hygiene, including breast feeding, scrupulous cleanliness at all times in the preparation and handling of food for children and continuous attention to diet will do much toward accomplishing this aim. As a precautionary measure all cases of infantile diarrhea should be regarded as bacillary dysentery unless proved otherwise. Prevention of epidemics of bacillary dysentery by gurading against massive dissemination of infection should be a major concern, particularly in prisons, camps, and institutions.

Epidemic measures.

1) Groups of cases of acute diarrheal disorder should be reported to the health officer at once even in the absence of exact diagnosis of cases.

2) Food, water and milk supplies should be investigated, general sanitation observed, and search for carriers made.

3) A reduction in the incidence of this disease may be expected from the prophylactic oral administration of chemotherapeutic and antibiotic agents under medical supervision in groups of persons exposed temporarily to a high rish of infection.

Echinococcosis (Hydatid disease)

1. Rigid control of slaughtering of herbivorous animals so that dogs do not have access to scraps of uncooked meat. (Dogs are infected only by the larval forms found in cysts in other animals).

2. Thorough treatment with proper antihelminthics of all dogs in the community in areas of

endemic prevalence.

3. Education of school children and adults as to the mode of spread of this disease in endemic areas. Warning not to let dogs lick faces or hands.

4. Licensing and periodic examination of dogs. Reduction of dog population in endemic areas.

5. Systematic clinical radioscopic and serologic examination in the schools and among the personnel of rural establishments as well as warehouses for animal products in areas of endemic prevalence.

6. Poisoning and trapping of wild or semi-wild carnivorous animals where the disease is widespread.

Encephalitis Lethargica. (Vienna or von Economo type).

Since the epidemiology is still unknown and although no insect vector is suspected, it is still wise to take cognizance of a possible arthropod vector.

Encephalitides, Arthropod-borne (St. Louis and equine type, Japanese B Type, Russian spring-summer and autumn fevers, Louping ill).

1) Early recognition and extent of disease in man is important.

2) Control of particular arthropod vectors, larval and adult forms.

3) Screening and use of repellents where necessary; use of mosquito bed nets in areas of prevalence.

4) Avoiding work exposure during hours when mosquitoes are biting, or using repellents at such times.

5) Education of the public as to the mode of spread and control.

Favus.

1. Elimination of common utensils such as hair brushes and combs.

2. Provision for adequate and intensive treatment and cure of cases of favus at hospitals and dispensaries to abbreviate the period of communicability of the patient.

3. Exclusion of patients from school or public places until lesions are healed.

Filariasis.

1. Education of the public concerning the mode of transmission of filariasis and methods of mosquito control.

2. Anti-mosquito measures against the transmitting mosquito. Use of repellents.

Food Infections (Salmonellosis).

1. Elimination of rodents and other vermin from food-handling premises.

2. Thorough cooking of foodstuffs derived from sources of possible infection. Special attention to egg and fowl products. Strictest possible attention to refrigeration and cleanliness of food handling premises and practices. Stress should be put on cleanliness of hands of food-handlers and on protection of foods from vermin during processing and storage.

3. Food-handlers should not be permitted to work while suffering from diarrhea.

4. Also general preventive measures for paratyphoid and typhoid fever.

Food Poisoning: Bacterial Intoxications.

A. Staphylococcus.

1. Temporary exclusion from food-handling of persons suffering from pyogenic skin infections, especially those of hands.

2. Prompt refrigeration of sliced and chopped meats and of custards and cream fillings to avoid multiplication of staphylococci accidentally introduced; filling of pastries with custard immediately before sale or adequate heat treatment of the finished product. Avoid improper care of left-over foods.

3. Some health authorities have forbidden sale of custard-filled products during summer months.

B. Botulism.

1. Government control by regulation and inspection of commercial processing of canned and preserved foods.

2. Education of housewives and others concerned with home canning of foods in essentials of safe processing, as to time, pressure and temperature factors.

3. Education in value of boiling home canned green and leafy vegetables before serving, and thorough cooking of sausage and other meats and fish products.

4. Epidemiological investigation for other cases. Search for limber-neck in chickens.

Foot and Mouth Disease.

1. All infected animals and all animals exposed should be immediately slaughtered and burned or buried.

2. The premises and all materials that might possibly be contaminated with the virus should be carefully cleaned and disinfected.

3. Test animals should be put into the premises to graze and feed and come in contact with everything that might have been infected by the virus to observe whether the premises are safe.

4. The infected should be rigidly quarantined against unauthorized visitors, both human and animal (including such animals as chickens and dogs).

5. The shoes and clothing of persons leaving the premises should be disinfected with sodium hydroxide.

6. Milk, butter and cheese from infected or suspected area should be pasteurized.

7. For those persons who must come into contact with infected materials ordinary hygiene precautions should be practiced.

Gonorrhea.

1. Provision of adequate diagnostic facilities, including laboratory facilities, for identification of the gonococcus by microscopic examination and by cultural methods.

2. Provision of facilities for the prompt and adequate treatment of infected persons with an appropriate therapeutic agent under medical supervision.

3. Public education as to the nature of gonorrhea and other venereal diseases, their clinical characteristics, prevalence, mode of transmission, and particularly as to how to avoid infection and to secure prompt examination and treatment if indicated.

4. Repression of commercialized prostitution and of clandestine sex promiscuity and of associated excessive use of alcoholic beverages, with the cooperation of appropriate social and law enforcement agencies.

5. Restriction of advertising of services or medicines for self treatment and of prescribing of treatment by persons other than physicians.

6. Use of prophylactic silver solution or similarly effective agent in the eyes of the new born.

7. Personal prophylaxis should be taught and made available for use before or immediately after sexual intercourse to those apt to expose themselves to infection.

8. Prevention of infection in persons exposed by extra-marital sex contacts can within certain limits of time be made highly effective by the pre-exposure use of suitable doses of an appropriate antibiotic by mouth.

9. Disinfection of discharges from lesions and articles soiled therewith.

Granuloma Inguinale.

Same general measures as for gonorrhea except that prophylactic use of silver nitrate solution in the eyes of the new born does not apply here.

Haverhill Disease (Rat-bite Fever)

1) Rat control and eradication programs.
2) Pasteurization of milk.

Hemorrhagic Jaundice (Leptospirosis)

1. Rat control by ratproofing, trapping and poisoning and reducing food supply.

2. Sanitary disposal of human wastes in civil and military environment.
3. Protection of workers exposed to infection by preventing organisms from entering through the skin by the use of boots and gloves and by other measures to limit the entrance of infectious agents through the mouth.
4. Appropriate antibiotic treatment of infected dogs.

Hepatitis, Infectious.

1. Good community sanitation and personal hygiene, with particular emphasis on sanitary disposal of respiratory discharges and feces and concurrent disinfection of such discharges from patients.
2. Isolation during first week of illness.
3. Proper technique to prevent possible transmission through administration of blood or blood products from an infected donor or through use of poorly sterilized syringes and needles.
4. Official requirement that all human plasma and serum intended for human use be suitably exposed to ultraviolet light radiation for destroying the virus.
5. Investigation of source of infection and education of public in the modes of transmission and control.

Epidemic measures:

1. Special efforts to improve sanitary hygiene practices in the community with the object of reducing fecal contamination of foods and water and carelessness in disposal of nose and mouth discharges.
2. Education of the public in the nature of the disease and its modes of transmission and the individual precautions to be taken to reduce opportunities of exposure to infection.

Hepatitis, Serum.

Control measures are practically the same as for infectious hepatitis.

Histoplasmosis.

1. Concurrent disinfection of all discharges from skin lesions, from necrotic lymph nodes, the sputum and articles soiled with these.
2. Lack of knowledge of epidemiology of this disease prevents application of practical measures, and makes thorough investigation of cases very important.

Hookworm Disease (Ancylostomiasis).

1. Education as to dangers of soil contamination and methods of prevention.
2. Prevention of soil contamination by installation of sanitation disposal systems for human discharges, especially sanitary privies in rural areas, and education of the public in the use of such facilities.
3. Personal prophylaxis by cleanliness and the wearing of shoes.

Impetigo Contagiosa.

1. Personal cleanliness, particularly the avoidance of common use of toilet articles among children and control of pediculosis and scabies.
2. Prompt treatment of the first case in a group of children will shorten the period of communicability and prevent extension of lesions to new sites as well as to other children.
3. Prompt treatment of parasitic infections of the skin.

Epidemic measures:

1. Intensification of educational efforts to improve personal hygiene, reduce parasitic skin diseases, encourage prompt treatment and early reporting of cases.
2. Sanitary supervision of bathing pools, beaches, children's play grounds, gymnasiums,

Influenza:

1. During epidemics, efforts should be made to reduce opportunities for direct contact infection, as in crowded halls, stores and street cars. Kissing, the use of common towels, glasses, eating utensils or toilet articles should be avoided. In isolated population groups and institutions, infection has been delayed and sometimes avoided by strict exclusion of all visitors. The closing of the public, parochial and private schools, has not been effective in checking the spread of infection. To minimize the severity of the disease, and to protect the patient from secondary infections and thus reduce mortality, patients should go to bed at the beginning of an attack, and not return to work without the approval of their physician.

2. Large aggregations of young adults unaccustomed to such association create a danger of spread of influenza when it is prevalent, especially when the individuals are subject to chilling, much fatigue or deprivation of customary bodily comforts, and such aggregations are to be avoided as far as possible.

3. Crowding of beds in hospitals and institutions to accommodate increased numbers of cases and other inmates is to be especially avoided. Increased spacing between beds in wards and dormitories should be carried out to reduce the risk of attack and of the occurrence of pneumonia.

4. Vaccination may be desirable in certain large groups during the winter or when an epidemic appears imminent.

Kala Azar (Visceral leismaniasis).

1. The repeated spray-painting of the walls of homes and other resting places of Phlebotomus at appropriate intervals with effective insecticides having residual action. For best results this spray-painting should cover all homes in the endemic area.

2. In the absence of residual insecticidal action, nightly disinsectization of sleeping and living quarters with liquid spray or aerosol insecticides.

3. Avoidance of known endemic areas.

4. The use of an insect repellent carefully applied to the exposed parts of the body for persons remaining after sundown in endemic areas.

5. Sanitary housing with adequate light and ventilation. No vegetation should be allowed close to houses in endemic areas. All animals should be kept away from houses. Damp ground floor residences should be avoided. Removal of thatch on roofs and cementing of floors.

6. Provision for diagnosis and large scale treatment campaigns.

7. Destruction of all stray and infected dogs where disease is widespread.

8. Education of the population concerning the mode of transmission of kala azar and methods of sandfly control.

Kerato-Conjunctivitis, Infectious (Superficial Punctate keratitis, Nummular Keratitis).

1. Education as to personal cleanliness and as to danger of use of common towels and toilet articles.

2. Avoidance of contact of hands with conjunctival or nasal discharges and disinfection of such discharges and articles contaminated therewith.

3. Aseptic technic in all professional care of patients with eye disease and injuries.

Leishmaniasis (American); Mucocutaneous Leishmaniasis, Espundia, Uta, Bubas.

Same general measures as for Sandfly Fever.

Leprosy.

1. In endemic areas leprosy is usually contracted in childhood but it may be acquired in adult life. Infants should be separated from leprous parents at birth. In educational efforts, stress need be placed upon the greater risk of exposure in early life.

2. Lack of information as to the determining factors in the spread and communication of the disease makes any but general advice in matters of personal hygiene of no value.

3. As a temporary expedient, patients may be properly cared for in general hospitals or if conditions of the patient and his environment warrant, he may be allowed to remain on his own premises under suitable regulation.

4. In those parts of the United States in the temperate zone farther north where the disease shows no tendency to spread, suitable medical and nursing care of infected persons is sufficient.
5. Concurrent and terminal disinfection should be practiced.

Lymphocytic Choriomeningitis.

1. General cleanliness of home and place of work, with elimination of mice therefrom.
2. Concurrent disinfection of discharges from nose and throat, urine and feces, and articles soiled therewith.
3. Investigation of home and place of employment for presence of mice and arthropods.

Lymphogranuloma Venereum (Inguinale) and Climatic Bubo.

Same general measures as for gonorrhea except that prophylactic use of silver nitrate solution in the eyes of the new born does not apply here.

Malaria.

1. Employment of known measures for destroying larvae of anophelines and the eradication of breeding places of such mosquitoes.
2. Blood examination of persons living in infected centers to determine the incidence of infection.
3. Screening sleeping and living quarters; use of mosquito nets.
4. Killing mosquitoes by sprays and other means in quarters where persons may be exposed to them.
5. Education of the public as to the mode of spread and methods of prevention of malaria.
6. Adequate treatment of persons with clinical attacks of malaria.
7. Liberal use of suitable repellents applied to the skin or clothes by persons unable otherwise to protect themselves against anopheline mosquitoes.
8. Routine oral administration of suppressive drugs for persons exposed to infection and unable to avoid anopheline mosquitoes.

Measles (Rubeola).

Measles virus vaccines are available and effective and should be administered routinely to all children.

Epidemic measures:

1. Daily examination of exposed children and known susceptible adult contacts, with recording of body temperature. Isolate promptly susceptible persons exhibiting a rise of temperature of 0.5° C. (1.0° F.) or more, pending diagnosis.

2. Schools should not be closed nor classes discontinued; provide daily observation of children by physician or nurse and remove sick children promptly.

3. In institutional outbreaks, protective doses of measles immune (gamma) globulin to all susceptibles to check spread of the disease and to reduce fatality. If new admissions be unavoidable, protect them also. Exclude visitors under 16 years of age, whether the outbreak be in the institution or in the community. Removal of patients during the preeruptive period may prevent an outbreak.

4. In non-immunized rural villages of lesser developed countries, measles is a highly fatal disease. Characteristically it occurs in periodic epidemics, being absent in the intervals. Outbreaks progress slowly among preschool children compared with school children and generally so when the start is during a long school vacation. The course is frequently over several months. Prompt community immunization by vaccination on first report of cases has the potentiality of restricting outbreaks, especially among young children where fatality is greatest.

Meningococcus Meningitis (Cerebrospinal Fever, Meningococcemia).

1. Education as to personal cleanliness and necessity of avoiding contact and droplet infection.
2. Concurrent disinfection of nasal and oral discharges and articles contaminated therewith.

3. Prevention of overcrowding such as is common in living quarters, transportation conveyances, working places and especially in barracks, camps and ships.
4. Cases should be isolated until recovery from acute illness.

Epidemic measures.

1. Increase the separation of individuals and the ventilation in living and sleeping quarters for such groups of people as are especially exposed to infection because of their occupation or some necessity of living conditions.
2. If a community—civil, industrial, or military—be suffering from an unusual risk of infection and the general administration of chemoprophylaxis to exposed persons under medical supervision be practicable, small doses of an appropriate chemotherapeutic or antibiotic agent will lower markedly the carrier rate and prevent the spread of the disease.

Mononucleosis, Infectious (Glandular Fever).

Concurrent disinfection of nasal and oral discharge and articles contaminated therewith.

Mumps (Infectious parotitis)

Concurrent disinfection of eating and drinking utensils.

Onchocerciasis

1. Avoidance of bites by simulium flies, and use of repellents.
2. Control of simulium larvae in rapid-running streams by means of insecticides.
3. Treatment of microfilaria-infected patients by surgical removal of nodules and administration of appropriate filaricide.
4. Protection of cases from simulium flies.

Paratyphoid Fever.

Same general measures as for Typhoid Fever.

Pediculosis (Lousiness).

1. Direct inspection of the heads and, when necessary, of the body and clothing where lousiness is found in groups of either children or adults, particularly of children in schools, institutions and camp groups.
2. Provision of residual insecticide for freeing the persons and clothing of lice.
3. Concurrent disinfection of other members of the family.
4. Education in the value of bodily cleanliness by use of hot water and soap and of washing body clothing in a way to prevent the survival of lice.
5. Individual prophylaxis through use of insecticide applied at appropriate intervals to clothing as dust or by impregnation.

Pemphigus Neonatorum (impetigo of the New Born).

A. The infected individual, contacts and environment:
1. Provision of adequate facilities for early diagnosis and efficient treatment will usually prevent grave results.
2. Suitable isolation and aseptic technic should be observed when a case appears in a nursery for the new born.
3. Exclusion of attendants with sores on their hands or faces from service of infants.
4. Interruption of admission of maternity patients or premature or other new born infants to the hospital, in case of epidemic, until new cases have ceased to appear in the institution and the lesions on infected infants and attendants have healed.
5. The vernix and blood are gently wiped away from the folds of the skin of the new born infant. Noting the delicacy of the skin, this is best accomplished by the use of warm, sterile

mineral oil on sterile cotton or soft sterile gauze. No water or oil bath is given during the first week or 10 days after birth. Each time the diaper is changed, sterile oil should be applied to the soiled or wet areas of the skin. Subsequent use of soap and water while the infant resides in the hospital should be limited to once a week. Scrupulous attention must be given to aseptic precautions, and to bedding, furnishings, gowns and masks of attendants. Visitors should be excluded from nurseries. Parents or nurses who have colds, pimples or dirty hands should not handle the infants, who should also be kept away from contact with street clothes.

Pertussis (whooping cough).

1. Immunization program directed especially toward protection of infants and children in early childhood.
2. Educational measures to inform the public, particularly parents of infants of the dangers of pertussis and of the advantages of immunization in infancy.
3. Separation of cases from susceptible children. Exclusion of cases and non-immune children from schools and public places for a period of assumed infectivity.

Plague.

1. Periodic surveys in plague endemic areas to determine the prevalence of rats and rat fleas. A rat flea index showing more than an average of one cheopis flea per rat examined requires action against fleas and rats.
2. Suppression of rats and vermin by use of known methods for destruction; especially destruction of rats on ships arriving from infected ports; periodic examination of rats, ground squirrels and other rodents for evidence of infection, in areas where the infection persists.
3. Ratproofing of buildings and elimination of breeding places and opportunities for the harboring and feeding of rats is a fundamental sanitary measure.
4. Ratproofing of ships.
5. Case should be isolated in hospital if practicable; if not, in a screened room free from vermin. In plague pneumonia, the attendants should wear hoods of closely woven cloth with goggles. Coveralls or complete gowns and trousers and rubber gloves drawn over sleeves should be provided and not removed from sick room until disinfected. Concurrent disinfection of sputum and articles soiled therewith in the pneumonic form of plague, and of purulent discharges in the bubonic form must be carried out. Terminal disinfection consists of thorough cleaning of walls, floors and furniture by washing with 5% solution of compound cresol, and airing of room for 48 hours. The bodies of persons dying of plague must be handled under strict aseptic precautions. Contacts should be quarantined for 6 days and disinfected.

Epidemic Measures:

1. Case finding teams are organized to search out new cases of infection and to apply emergency control measures.
2. Control teams have the obligation of focal area control of fleas and other insect vectors and of the conduct of anti-rat campaigns.
3. Area quarantine may be essential to control extensive outbreaks, with attention to disinfestation and immunization.
4. Personal protection against fleas by weekly dusting of underclothing with insecticide powder, insect repellents against fleas, and protective clothing.
5. Each government should immediately notify adjacent governments and the World Health Organization.
6. Measures on departure and arrival of vessels and aircraft from and to the infected area should be taken.
7. Merchandise coming from an infected area should not be discharged except with necessary precautions.
8. All ships should be periodically deratized and all ports and airports should be periodically deratized and protected against insect vectors.
9. The sanitary measures should be applied to land traffic, but should not exceed those of sea and air traffic.

Pneumonia - Acute Lobar, Pneumococcal.

1. Whenever practicable and particularly in institutions, barracks, and on shipboard, crowding in living and sleeping places should be avoided. The general resistance should be conserved by good food, fresh air, sufficient sleep, temperance in the use of alcoholic beverages and other hygienic measures.

2. Isolation of case and concurrent disinfection of nasal and oral discharges.

Bacterial Pneumonia, other than Pneumococcal.

Same as pneumococcal pneumonia.

Primary Atypical Pneumonia.

Same as for pneumococcal pneumonia.

Poliomyelitis: Preventive measures:

1. Active immunization of all susceptible persons against the three types of poliovirus. Give priority to ages with highest incidence and to selected groups at unusual risk. Immunization may begin as early as 6 weeks of age although delay to 4 to 6 months avoids the depressive effect of maternal antibody on immune response.

2. Health education of the public on the advantages of immunization in early childhood, and on modes of spread.

Epidemic measures:

1. Institute mass vaccination with oral vaccine at the earliest indication of an outbreak. Use monovalent vaccine of the same virus causing the outbreak.

2. Organize mass vaccination campaigns to achieve the most rapid and complete immunization of epidemiologically relevant groups, especially younger children. Locate vaccination centers in relation to population densities, taking advantage of normal social patterns; schools often meet these criteria. Requiring individual records of each person vaccinated slows distribution markedly; a simple tally by age group is rapid and practical. Subsequent community sample surveys give adequate measure of the numbers immunized.

3. With the use of mass immunization, disruption of community activities such as closing schools and other places of population aggregation, is no longer necessary.

4. Postpone elective nose and throat operations until after the epidemic has ended.

5. Provide facilities in strategically located centers for specialized medical care of acutely ill patients and rehabilitation of those with significant paralysis.

Psittacosis and other Ornithosis diseases.

1. Strict regulation of traffic in birds of parrot family based on quarantine and laboratory examination, but prohibition of such traffic is preferable.

2. Quarantine of homes and pet shops known to have harbored infected birds until thoroughly cleaned.

3. Education of community in the danger of making house pets of birds of the parrot family particularly when the birds have been recently imported or are of doubtful history as to contact with other and especially with sick birds.

4. Control of mosquitoes or other arthropods where indicated.

5. Isolation of case during the febrile and acute clinical stage. Attendants should wear gauge masks, 8 layers of 40 to 48 threads per inch or 16 layers 20 to 24 threads per inch. All discharges shall be disinfected. Incriminated birds should be killed, immersed in 2% cresol and burned before feathers dry. Buildings which housed birds should not be used by humans until thoroughly cleaned and disinfected.

Q Fever.

1) Precaution against ticks.

2) Pasteurization or boiling of milk.

3) Special precautions when indicated at slaughter houses and stock yards where cattle and sheep are handled.

Rabies.

See discussion on Rabies Control.

Rat-bite Fever (Sodoku).

Rat surveys and reduction of rat population. Avoidance of rat bites.

Relapsing Fever.

A. Louse-Borne.

1. Routine application of insecticide with residual effect to populations living in conditions favoring the development of lousiness.
2. Individual prophylaxis through use of insecticides at appropriate intervals to clothing.
3. Isolation is not required after delousing cases and household contacts.
4. Improvement of living conditions, hygiene of person and clothing.
5. During epidemics, delousing programs must be immediately set up.

B. Tick-Borne.

Avoidance of tick infested caves, camp sites, shacks, and ground areas. The ticks live in the soil and bite during the night or in darkness. They can live for years without feeding and remain infective. Exposed persons should use a tick repellent on socks and trousers. Clothing and body should be carefully searched morning and night.

Rheumatic Fever (Acute Rheumatic Fever, Acute Rheumatism).

1. Careful medical examination of children with vague symptoms, e.g., malaise, pallor, failure to gain weight, epistaxis and transient aches and pains; appropriate laboratory tests should be included.
2. Emphasis on the fact that rhematic activity may begin insidiously and may cause incapacitating heart disease.

Rickettsialpox.

Control programs against mice and rats and their arthropod parasites.

Ringworm (Dermatophytosis).

A. Ringworm of the Scalp (Tinea Capitis).

1. Cleanliness of hair and scalp.
2. Prompt and persistent treatment of infection. In case of infections with Microsporon audouini, X-ray epilation followed by fungicide treatment is the method of choice. This results in the most rapid cure and least loss of school time. Precautions should be taken to prevent reinfection after x-ray treatment.
3. Education of parents and school authorities in ways of spread of the disease and measures for control.
4. Provision for individual storage of clothing in school.
5. Provision for separate, isolated classrooms for education of children with the condition may be found necessary. These should be so set up that children waiting final decision as to freedom from infection may not be reinfected.
6. During epidemics, special provisions for diagnosis and treatment must be set up.

B. Ringworm of the Body (including groin and feet).

1. Cleanliness of body and underclothing.
2. Thorough drying between toes after bathing.
3. Children should be excluded from school until they are under treatment. Concurrent disinfection of clothing and shoes.
4. Prompt and persistent treatment of lesions.
5. Protection of feet against contamination by use of sandals in showers and dressing rooms and areas used by people with bare feet.
6. Wearing of properly fitted and ventilated shoes.
7. Cleanliness should be maintained in gymnasiums, shower rooms and the like.

Rocky Mountain Spotted Fever (Tick-Borne)

1. Personal prophylaxis by avoidance of tick-infected areas when feasible, by careful removal of ticks from the person as promptly as possible without crushing and by protection of the hands when removing ticks from animals.
2. The destruction of ticks by clearing and burning vegetation, and the destruction of small

mammalian hosts of ticks in infected zones have been suggested. There is little evidence, however, that much has been accomplished in limiting the disease by such methods. Effective repellents are being developed.

3. Vaccination appreciably lessens the chances of infection and lowers the case fatality rate. The protection lasts for 1 or 2 years. The vaccine is of no value after the infection has been acquired, nor is it of value in treatment. Hyper-immune rabbit serum is available for treatment.

Rubella (German measles)

Efforts to control rubella are prompted by the hazard of significant congenital defects in offspring of women who acquire the disease during pregnancy. The most common defects are congenital cataract, heart disease and deaf mutism. The risk is of the order of 20% dead or deformed infants after maternal rubella during the first trimester of pregnancy.

Preventive measures:

No attempt should be made to protect female children in good health against exposure to disease before puberty. Deliberate exposure is recommended by most authorities. A vaccine is now well advanced in its experimental stage.

Sandfly (Phlebotomus or Pappataci) Fever

1. Screening sleeping and living quarters; use of insect nets of 25-30 meshes per inch, which should be sprayed with an insect repellent before entering. Window screens should be sprayed nightly.
2. Killing adult sand flies in living quarters.
3. Elimination of breeding places in proximity to dwellings.
4. Avoidance of known infected areas.
5. The use of an insect repellent carefully applied each evening to the exposed parts of the body.

Scabies (The Itch).

Cleanliness of body and underclothing and bed covering especially. In case of epidemic, provision should be made for convenient facilities for prompt treatment.

Schistosomiasis.

1. Sanitary disposal of feces and urine.
2. Treatment of the infected persons will reduce communicability.
3. Education of people in areas regarding method of transmission. People should be warned not to bathe in contaminated streams and persons whose occupations require them to wade in contaminated waters should be cautioned and be provided with suitable waterproof garments.

Smallpox (Variola).

1. General vaccination in early infancy, revaccination of children on entering school, and of entire population when the disease appears in a severe form.
2. Preservation of smallpox vaccine below freezing up to the hour of vaccination. This includes shipment between cakes of dry ice.
3. In order to avoid possible complications or secondary and subsequent infections at the site of vaccination, it is important that the vaccination insertion be as small and superficial as practicable, not over one-eighth inch in any direction, and that the site be kept dry and cool. The use of shields or other dressings is to be condemned. The multiple pressure method is recommended. Primary vaccination at as early an age as possible is desirable. The time of vaccinations should be adjusted to avoid skin lesions elsewhere on the body, and in older children to avoid the warmer months. Particular care should be used in primary vaccinations in persons beyond the age of infancy.
4. Isolation in screened rooms, preferably in a hospital for period of infectivity and disinfection of all articles associated with the sick room by high pressure steam or by boiling. Quarantine of all contacts until vaccinated and declared immune.
5. During an epidemic, widespread vaccination should be done, rigorous enforcement of quarantine and isolation and education of public should be carried out. The usual procedure of informing neighboring governments and the World Health Organization, etc., should be done.

Streptococcal Infection--Respiratory.

Both general and epidemic measures for: Scarlet Fever, and Streptococcal Sore Throat (Streptococcal Nasopharyngitis, Streptococcal Tonsilitis "Septic Sore Throat").

1. Provision for throat cultures.

2. Education in the danger from infection with hemolytic streptococci whether or not scarlet fever is manifest in the patient.

3. Pasteurization or boiling of milk and inspection of cows for mastitis.

4. Exclusion of infected persons from handling milk, or milk products or other foods subject to contamination.

5. In the absence of an epidemic, the milk from any cow with evidence of mastitis should be excluded from sale or use as a protection in addition to pasteurization.

6. Isolation, concurrent disinfection of objects contaminated by case, terminal disinfection by thorough cleaning of contaminated objects, scrubbing of floors and other horizontal surfaces and sunning of blankets should be carried out.

Epidemic measures:

1. Determination should be made whether an outbreak is caused by personal contact or by contaminated food or milk.

2. Daily inspection for 1 week by physician or nurse of school children exposed or potentially exposed.

3. Segregation of persons with evidence of upper respiratory infection throughout the clinical course of their disease.

4. Prompt investigation of any group of cases as to possibly contaminated milk supply with exclusion of suspected milk supply from sale or use until pasteurized.

Streptococcal Infection--Other Than Respiratory.

Erysipelas

Personal cleanliness and avoidance of transferring infecting organisms into the broken skin.

Puerperal Infection (Puerperal Septicemia)

1. Strict asepsis in obstetrical procedure with special attention to possible contamination by invisible spray from mouth and nose of attendants as well as by direct transmission from hands, instruments, etc.

2. Protection of patient (during labor and postpartum period) from attendants, visitors and other patients with respiratory or skin infection.

3. Bacteriologic search for carriers among attendants, physicians, nurses and nursemaids.

4. Education of women in the hazard of self-interruption of pregnancy.

5. Strict isolation of case while infectious discharges persist.

6. Concurrent and terminal disinfection same as for scarlet fever.

Syphilis.

1. Provision at public expense of adequate clinical and laboratory facilities for diagnosis.

2. Provision at public expense of adequate treatment facilities.

3. State legislation requiring antepartum serologic tests and legislation making physical and serological examinations before marriage compulsory.

4. Mass serological examinations of special groups, such as employees in industry, residents of accessible localities where syphilis is highly prevalent, and examinations prior to entrance into the military services.

5. Repression of commercialized prostitution and of clandestine sex promiscuity, and of associated use of alcoholic beverages, with the cooperation of appropriate social and law enforcement agencies.

6. Restriction of advertising of services or medicines for self-treatment, and of the prescribing of treatment by persons other than physicians.

7. Public education as to the nature of syphilis and other venereal diseases, their clinical characteristics, prevalence, mode of transmission and particularly how to avoid infection and to secure prompt examination and treatment if indicated.

8. Personal prophylaxis should be taught and made available for use before or immediately after sexual intercourse to those apt to expose themselves to infection.

Tetanus.

1. Active immunization is desirable for all those likely to be exposed to infection.
2. Active immunization is advised in infancy or early childhood, preferably combined with the administration of diphtheria and pertussis immunization. In addition to the initial immunization another dose should be given within a year, and renewal doses at the time of each injury from which there is danger of tetanus. Stimulating injections should probably be given at intervals of 5 years.
3. In the absence of adequate previous immunization with tetanus toxoid, the prophylactic use of tetanus antitoxin is recommended where wounds have been acquired in regions where tetanus is prevalent, and in all cases where contaminated material may be imbedded in the wound.
4. Removal of all foreign matter as early as possible from all wounds.
5. Educational efforts in industry and on farms.
6. Licensing of midwives authorized to attend confinements, with professional supervision and education of such persons as to methods, equipment and technic of asepsis.

Trachoma.

1. In areas where trachoma is prevalent, careful and systematic examination of the eyes of children is indicated, especially those attending school.
2. The use in common of toilet articles and towels should be prohibited.
3. Case should be isolated except when case and family understand and are cooperative in carrying out proper hygiene. Concurrent disinfection of eye discharges and articles soiled therewith is necessary.

Trichinosis.

1. Inauguration of local and state meat inspection to assure adequate processing of all pork products not processed under federal inspection, and customarily eaten without further adequate cooking by the consumer.
2. Encouragement of farmers and hog raisers in the use of standard swine sanitation practices which will reduce opportunity for trichina infection in swine, such as:
   a. Control of rats, particularly on farms and around hog-raising establishments and stockyards.
   b. Burial or other adequate disposal of rat and swine carcasses to prevent hogs from feeding on them.
   c. Burning, burial, or adequate disposal of swine offal to prevent swine or rat feeding on it.
3. Elimination of the current practice of feeding uncooked garbage and offal to swine and the adoption and enforcement of suitable laws and regulations ensuring cooking such material before its consumption by swine.
4. Cooking of all fresh pork and pork products by the consumer at a temperature and for a time sufficient to allow all parts of the meat to reach a temperature of at least 65.6°C. (150°F.), unless it be known that these meat products have been processed under federal or other official regulations adequate for the destruction of trichinae.

Trypanosomiasis, African (Sleeping sickness)

1. Widespread blood-sterilizing campaigns by mass injection of local population with appropriate chemotherapeutic agents in order to lower the index of new infections.
2. Mass movement of infected population to fly-free area.
3. Wide, and if necessary, repeated clearings of brush around villages, along lines of communication, near houses, roads, etc. More likely to be successful against G. palpalis than against other insects.
4. A concentration of the population in relatively large villages.
5. Fly control by all practicable means including use of insecticides with residual action, trapping, flypaper, handnets, etc.
6. Destruction of pupae collected from breeding places.
7. Segregation of big game into game reserves away from human habitation for G. morsitans.
8. Education of the population as to the mode of spread and methods of prevention of trypanosomiasis.
9. Individual protection can be achieved temporarily by the administration of appropriate chemoprophylactic agents. This does not prevent infection but mitigates the pathogenicity of the trypanosome.

Trypanosomiasis, American (Chagas' Disease).

1. Construction or repair of dwellings so that they do not afford hiding places for the insect vector or shelter for the wild hosts.
2. Elimination of infected domestic animals and destruction of the habitations of wild hosts in known endemic areas.
3. Use of a bed net in houses infested by the vector.
4. Systematic attack upon vectors through use of effective insecticides having residual effect.

Tuberculosis, Pulmonary and other types.

1. Education of the public in regard to the danger of tuberculosis, the mode of spread and methods of control, with special stress upon the danger of exposure and infection in adolescence and early adult life.
2. Provision of X-ray and clinical facilities for examination of contacts and suspects, public health nursing service for home supervision of patients and for ensuring examination of contacts, and dispensary service for continuation of collapse therapy in ambulant cases and for clinical supervision of patients not otherwise so supervised. Photofluorographic screening of entire adult population periodically and adequate follow-up.
3. Provision of adequate sanatorium facilities for isolation and treatment of active cases of the disease. At least 2 beds should be provided per annual tuberculosis death in the community.
4. Routine X-ray examination of all in-patients and out-patients in general and mental hospitals, and of selected groups of industrial workers and other adult population groups. Routine tuberculin testing of children is not a procedure for case finding.
5. Elimination of the inhalation of silica dust in dangerous quantity in industrial establishments and trades.
6. Pasteurization or boiling of all milk and milk products.
7. Improvement of habits of personal hygiene and betterment of living conditions among the underpriviliged.
8. Separation of babies from tuberculous mothers at birth.
9. Eradication of tuberculosis from dairy cattle.
10. Patients with open lesions should be prohibited from handling foods or attending upon children. Their sputum and articles soiled therewith should be disinfected.
11. BCG vaccination is to be recommended for highly susceptible racial groups who are exposed and for persons subject to intense exposure such as family contacts, particularly infants and young children and for persons attending infectious cases, particularly medical students and student nurses.

Tularemia.

1. Avoidance of the bites of, or handling of, flies and ticks when working in infected areas during the seasonal incidence of bloodsucking flies and ticks.
2. The use of rubber gloves by persons engaged in dressing wild rabbits wherever taken, or when performing necropsies on infected laboratory animals. Employment of immune persons for dressing wild rabbits or conducting laboratory experiments. Thorough cooking of meat of wild rabbits.
3. Avoidance of raw drinking water in areas where the disease prevails among wild animals.
4. Concurrent disinfection of discharges from ulcers, lymph nodes, or eyes.

Typhoid Fever.

1. Protection and purification of public water supplies; construction of safe private supplies.
2. Sanitary disposal of human excreta.
3. Pasteurization or boiling of milk and milk products including cheese.
4. Limitation of collection and marketing of shellfish to those from approved sources.
5. Supervision of other food supplies and of food-handling practices.
6. Fly control and protection of food against fly contamination by screening and appropriate use of insecticides with residual action.
7. Immunization of persons subject to unusual exposure by reason of occupation or travel, those living in areas of high endemic incidence of typhoid fever and those for whom immunization

can be systematically and economically applied, as in the military forces and institutional populations. Family contacts of carriers should be immunized.

8. Discovery and supervision of typhoid carriers, and their exclusion from the handling of foods.

9. Instruction of convalescents and chronic carriers in personal hygiene, particularly as in sanitary disposal of excreta, hand-washing after use of the toilet, and restraint from acting as food handlers.

10. Education of general public and particularly food handlers concerning mode of typhoid spread.

Epidemic measures:

1. Boiling of milk or pasteurization or exclusion of suspected milk supplies and milk products on epidemiologic evidence pending elimination of the cause of contamination.

2. Chlorination under competent supervision of suspected water supply or its exclusion. All water used for drinking must be chlorinated or boiled before use.

Typhus.

Epidemic or Classical (Louse-borne)

1. Vaccination of exposed population.

2. The remaining measures are same as for louse-borne relapsing fever.

Epidemic measures:

1. Organized and systematic delousing, and vaccination of population groups, centering about households of infected persons. Travelling permitted without restraint after thorough application of insecticide with residual effect.

2. Each government should immediately notify adjacent governments and the World Health Organization and carry out other international measures for cholera or plague.

Endemic or Murine Typhus (Flea-borne).

Rodent control and associated insect control.

Scrub Typhus or Tsutsugamushi Disease (Mite-borne).

1. Areas of known soil or rodent mite infestation should be prepared as fully as possible before use for human occupancy, employing native labor whenever it is available. All grass and scrub should be cut level with the ground, and, after drying, collected and burned or hauled away. It is highly desirable to burn over the camp area with a power oil sprayer or flame thrower. Underbrush in adjacent jungle strips should be cleared out in a similar manner and ground animals killed. If miticides for disinfection of soil be available, they should be used.

2. Sleeping on the ground should be avoided. When practicable, cots or other structures should be provided to keep the bedding from contact with the ground.

3. At the earliest time after exposure, bathing with thorough soaping and scrubbing of the skin with a rough cloth.

4. Impregnation of clothes with antimite fluids and powders will serve as a satisfactory method of individual control. Such measures are particularly applicable to personnel working in known endemic foci.

Undulant Fever. (Brucellosis)

1. Pasteurization or boiling of milk and dairy products whether from cows or goats.

2. Search for infection among livestock by agglutination reaction and elimination of infected animals from the herd by segregation or slaughter.

3. Education of the public and particularly workers in slaughter houses, packing houses and butcher shops, as to the nature of the disease, the mode of transmission and the danger of handling carcasses or products of infected animals.

4. Meat inspection, especially of pork and pork products.

5. Vaccination of calves.

6. Care in handling and disposal of all discharges and the fetus from aborting animals and disinfection of area contaminated.

Vincent's Infection.

1. Education in oral hygiene.

2. Sanitation programs relating to eating utensils, towels, drinking cups and personal articles.

Vulvovaginitis in Children.

1. Prevention of contamination of the vulga and vagina of children with the vulvovaginal discharges of other persons, whether by fingers, thermometers, or other means.
2. Supervision of child-caring institutions and enforcement of scrupulous cleanliness and rigid sanitary precautions to avoid the introduction and spread of infection by isolation and concurrent disinfection.
3. Provision of adequate diagnostic and laboratory facilities.
4. Public education as to the nature of gonorrheal and other forms of vulvovaginitis in children, their mode of transmission and in personal cleanliness and hygiene.

Epidemic measures.

1. Immediate intensive treatment of reported areas.
2. Prompt search for and protection of preadolescent and younger girl children against a source of infection within the institution or group affected.
3. Education of those in charge of the children as to mode of spread and importance of personal cleanliness and daily hygiene of the children, their toilet facilities and their body clothing.

Yaws (Frambesia)

1. Free clinics, laboratory diagnosis service and treatment.
2. Information service for physicians, patients and public.
3. Promotion of adequate personal prophylaxis.
4. Education in schools, clinics, clubs, etc., as to methods of spread, prevention and treatment.
5. Concurrent disinfection of soiled dressings.

Yellow Fever.

1. In regions where yellow fever may occur, viscerotome service should be organized on a permanent basis to collect liver specimens from fatal cases of febrile illness of short duration. Immunity surveys of men and monkeys by neutralization tests in white mice are also useful to discover endemic-enzootic areas.
2. Control of Aedes aegypti breeding is the most important factor in the prevention of urban outbreaks of yellow fever and should be undertaken in towns and cities in countries in which the disease prevails endemically.
3. Active immunization of all persons necessarily exposed to infection because of residence or occupation is desirable. All travellers, especially those from countries where yellow fever does not exist should be vaccinated before embarking for areas of endemic or epidemic prevalence.
4. Cases should be isolated in screened quarters, spray-painted with insecticide having residual action, during the first 3 or 4 days of fever.

Endemic measures.

1. Urban or aegypti-transmitted yellow fever.
   a. Spray-painting with residual insecticide of interiors of all homes in community.
   b. Application of residual larvicide to all artificial water containers in community
   c. Mass vaccinations.
2. Jungle yellow fever.
   a. Mass vaccination of those approaching or entering forest.
   b. Avoidance of forest by the unvaccinated and by persons during the first 5 days after vaccination.
   c. Where non-immunized persons must enter limited forest areas, plane application of insecticide with residual effect must be used.
3. Immediate notification of adjacent governments and World Health Organizations and

carrying out of international measures as described under control measures for cholera.

Rabies Control: The Nature of the Disease.

Rabies or hydrophobia is a disease of warm blooded animals including man. The reservoirs include any of a large group of wild and domestic Canidae, including the dog, fox, coyote, wolf, and also cat, skunk, raccoon, opossum and other biting mammals. Vampire and fruit eating bats are infected in South and Central America. Infection of insectivorous bats recently have been recognized in the United States. It is caused by a filterable virus which is usually introduced into the body by the bite of a rabid animal. The bite punctures the skin and allows the virus, which is present in the saliva, to enter the body. The virus has also been found in the saliva of human cases during the convulsive period. Although the virus has a marked affinity for the nervous system, this affinity is also present for the salivary glands and to a lesser degree for other glandular tissues. The virus appears to travel along the nervous system and does not produce symptoms in the body until it reaches the brain. The average incubation period in man is two to eight weeks or longer, depending on the extent of the laceration and the site of the wound in relation to the richness of nerve supply and length of the nerve path to the brain. The average incubation period in dogs is two to four weeks. It may be as short as ten days and as long as six months or more. It takes about 3 or 4 weeks after vaccination for the maximum immunity to develop, therefore vaccination may not be effective in case of short incubation. The period of communicability in the dog is 3 to 5 days before the onset of clinical symptoms and through the clinical course of the disease. It is rarely communicated from man to man, but may be communicated through the saliva of a person sick with rabies if the contact's skin be broken.

From the time that symptoms of rabies first show in a dog to the time of the dog's death is almost always within 7 days, and practically never longer than 10 days.

Once the symptoms of rabies become manifest, the disease is fatal.

Besides the animals listed in the above table, rabies in the United States has been found in foxes, coyotes, squirrels, opposums, rabbits, rats, mice, raccoons, muskrats, gophers, weasels, wildcats, groundhogs, minks, badgers, wolves, woodchucks, skunks, and civet cats. No cases of human rabies was reported for 1967. There are, of course, many more actual cases than are reported. Studies seem to indicate that the mortality among untreated humans is about 9%, and that among treated humans it is about 0.08% to 0.5%. Rabies is fatal once the signs and symptoms set in.

Three types of rabies can be distinguished in dogs.

Furious rabies: The early manifestations are congestion of the mucous membranes of the eyes and nose, slight elevation of temperature, restlessness, nervousness, easily startled, friendly but easily irritated, increased muscle tension, pointing ears. The dog does not remain quiet for long; it eats indigestible materials; the eyes do not blink, the pupils dilate, and the conjunctiva becomes dry; the vocal cords may become weak and produce a howl-like bark; the dog will indiscriminately attack other animals. Later the dog developes a staggering gait, paralysis of the jaws set in, and finally convulsive seizures. Furious rabies has a long phase of excitation. The dog usually lives four to seven days after the onset of signs and sometimes as long as ten days. The less virulent the virus or the smaller the infecting dose, the more severe are the "furious" signs. Conversely, the more virulant the virus or the larger the infecting dose, the more evident are the "dumb" signs.

Dumb rabies: The dog becomes depressed, apathetic and sleepy. The mucous membrane of the eyes and nose becomes congested. The eye signs are the same as in the furious type. The muscles of the jaw, throat and voice become paralyzed. There is practically no irritability or tending to bite. There is marked incoordination and spasticity. Paralysis develops quickly. The dog becomes comatose, lies on side and moves eyes rhythmically. It seldom lives more than 3 days after the onset of symptoms.

Mixed type: Most dogs show a combination of both the furious and dumb types of rabies. The excitation period is short. The dog becomes restless, nervous and insensible to pain. This is followed by depression and paralysis.

Wherever possible, a veterinarian should be consulted to determine whether an animal has rabies. The traditional laboratory diagnosis of rabies has been by microscopic examination of the brain tissues. It has been known for a long time that some rabid cases have defied detection by the ordinary microscopic method. Webster and Dawson have devised a mouse inoculation test for diagnosis which has been found more sensitive than the microscopic method. This method has been able to detect many of the cases which the microscope misses. It has been shown that the microscope may fail to diagnose 10 to 15% positives which can be detected by the mouse inoculation test. Two other tests which help in diagnosis is the isolation of the virus from the submaxillary salivary glands of biting dogs which is done in a similar manner as the mouse inoculation test, and the serum-virus neutralization test for identification of the isolated virus.

The sanitarian may find himself in a quandary in circumstances where the use of the milk from suspected rabid cows is concerned. Rabies virus has been found in the milk of infected animals. It is probably present in the milk several days before the animal shows symptoms, just as it is in the saliva. A case of the transmission of rabies from a rabid mother to her infant has been cited. Other cases have been cited where suckling animals have been infected apparently through the milk. It is generally conceded, however, that there is no danger from the ingestion of infected milk unless there be abrasions on the lips or along the alimentary tract through which the virus may enter the circulation. Milk from cattle suspected of rabies should not knowingly be used for human consumption or fed to animals. Cows in herds that have been attacked by rabid dogs, but where infection is doubtful, should be carefully watched for possible symptoms, the milk being boiled or pasteurized meanwhile.

There is no authentic instance of the transmission of the disease by the bite of man, although this is possible. The bites of horses or other herbivorous animals are less dangerous because of their blunt teeth. Bites on the exposed surfaces of the body are more dangerous than through clothing, since the saliva may be wiped from the teeth while penetrating through the clothing. The gastric juices have a deleterious effect on the virus and pasteurization will kill the virus. The virus rapidly loses its potency when exposed to air and especially to sunlight, but if protected from heat, light and air the virus may retain its potency for sometimes. The possibility of developing the disease from saliva smeared materials is less if the skin be not broken.

There is no evidence that the dog or any other animal with the exception of the vampire bat can act as a symptomless carrier.

Fluorescent Antibody Test

It has been shown that this test can establish a highly specific diagnosis on specimens within a few hours, and that there is a high degree of correlation between the results of the fluorescent-antibody test and those of the mouse-inoculation test.

Biological test

The intracerebral inoculation of mice coupled with the microscopic examination of brain tissue for Negri bodies is still one of the most useful tests in the laboratory diagnosis of rabies and should be used whenever humans have been bitten by suspect animals and the fluorescent-antibody test is negative.

Treatment of Exposed Humans.*

Vaccines of Established Value

Vaccines have been of two main types: those containing live attenuated virus and those containing virus that has been inactivated by one of a variety of agents. The trend over the last 50 years has been toward inactivated vaccines, because they lend themselves more easily to centralized production, they keep better under field conditions, especially if lyophilized, and they provide increased assurance of safety. The most common types of brain-tissue vaccine in use today are the Semple type, using virus completely inactivated by incubation at 37°C. in the presence of phenol, and the Fermi type, incubated at 22° C. in the presence of phenol and still containing residual infectious virus. More recently, virus grown in duck embryos and inactivated by betapropriolactone has been widely used in the USA.

Duck-embryo vaccine was developed in an attempt to eliminate those factors in brain-tissue vaccines responsible for post-vaccinal complications of the central nervous system. Evidence today indicates that although this hazard has been reduced it has not been completely eliminated. Thus, there has been limited use of a suckling-mouse-brain vaccine in which the virus is inactivated by ultraviolet irradiation and of a suckling-rat-brain prepared by the Fermi method. Besides being apparently free from the "paralytic factor," vaccines prepared from the brain of suckling animals have the added advantage of high potencies because of higher virus content in the donor animal. However, they offer some practical problems as regards mass production.

Tissue-culture vaccines are being experimented with since they have been found to contain appreciably smaller amounts of extraneous material than do organ-suspension vaccines (this is true also of a vaccine made in very young chick embryos), and they have been found to be more antigenic.

Prevention of Rabies in Man

General considerations

Initiation of treatment in exposed persons should never await the results of laboratory diagnosis; in any event, local treatment is usually completed and serum and/or vaccine therapy instituted before the laboratory report is received. A report from the laboratory indicating absence of rabies usually justifies cessation of treatment. However, in some circumstances the physician may be justified in continuing or even initiating treatment despite such a report.

The value of the local treatment of wounds infected with rabies virus should be emphasized, including first-aid procedures and possibly the use of high-titre antirabies sera or their globulin fractions, both applied topically and infiltrated around the wound.

The combined administration of antirabies serum and vaccine, together with local treatment, provides the best possible prophylaxis of rabies in an exposed person. It is therefore strongly recommended that this procedure be adopted in all cases of severe exposure. It is not intended to suggest, however, that its use is not justified in all genuine cases of exposure, even of a mild nature, although it must be recognized that long-term experience has shown the use of a potent vaccine alone to be quite effective in mild exposures. Deleterious reactions are possible following the use of either antirabies serum or antirabies vaccine.

*The World Health Organization's Expert Committee on Rabies, Technical Report No. 321, 1966.

Improvements in the safety and effectiveness of rabies vaccines continue to be made. On the evidence of studies to date, vaccines of tissue-culture origin for human use appear feasible and offer potential advantages over existing products. However, vaccines of nervous-tissue or avian-embryo origin will of necessity be the vaccines available, at least during the immediate future. Clinical trials aimed at reducing the number of doses (usually between 14 and 21) of existing vaccines have been unsuccessful.

Prompt and adequate treatment of all bite wounds and scratches possibly contaminated with rabies virus is of paramount importance. When medical assistance is not promptly available, immediate first-aid procedures are recommended, including the flushing and washing of the wound with soap and water, detergent or other harmless fluids. Treatment by the physician should, where indicated, include adequate cleansing of the wound, thorough flushing and scrubbing with 20% soap solution and/or the application of a quaternary ammonium compound or other substance of proven lethal effect on rabies virus. Although judicious use of concentrated nitric acid in puncture wounds has its advocates, there is no evidence that this product is more effective than quaternary ammonium compounds or 20% liquid soap solution. Where possible, bite wounds should not be immediately sutured.

High-titre antirabies serum and its globulin fractions in liquid or powdered form used topically have been shown to be highly effective in preventing rabies in experimental animals. Their use should be considered in all cases of human exposure. Sensitivity to serum should be determined prior to its use. In patients, the nature of whose exposure merits use of antirabies serum, a part of the serum dose should be infiltrated into the tissue around the wound whenever feasible. The application of ordinary antiseptics and antibiotics or antitetanus procedures, when indicated, should follow the local treatment recommended above.

It is recommended that antirabies serum be given as promptly as possible after exposure. However, serum should be administered in all cases where this is practicable, irrespective of the interval between exposure and treatment. Serum should be administered intramuscularly in a single dose of not less than 40 International Units per kilogram of body weight and followed by a course of not less than 14 doses of vaccine. Because the administration of serum interferes with the production of measurable antibody induced by vaccine, booster injections of vaccine are recommended at 10 days, and at 20 days or longer after completion of the vaccine schedule.

Reactions to antirabies horse serum, even though the serum be concentrated and purified, occur with approximately the same frequency as with other sera of animal origin. Careful questioning about a past history of allergy and the routine use of an intradermal or ophthalmic test for sensitivity will avoid the risk of an immediate anaphylactic type of reaction. If the sensitivity test should be positive, the usual precautions of desensitization should be followed and, if possible, serum produced in another species should be used. Rabies immune human gamma-globulin is becoming available for the prevention of rabies.

Pre-exposure immunization

Persons who run an unusually high risk of repeated exposures, such as laboratory staff working with rabies virus, veterinarians, dog handlers, field naturalists, etc., should be protected by pre-exposure immunization. Such immunization may consist of a short course of 2 to 3 injections of a potent antirabies vaccine, preferably of a non-nervous-tissue type, at one month intervals, followed by a booster injection of vaccine 6 months later. The presence of serum-neutralizing antibodies in vaccinated individuals should be ascertained on a serum sample drawn one month after the booster injection. If negative, booster doses should be repeated until antibodies become demonstrable. Further booster injections should be administered at intervals of one to three years as long as the exposed person remains at risk.

Sufficient information is not available to permit firm recommendations as to the best procedure to follow when an immunized person who has demonstrated an antibody response in the past is exposed to rabies. The following recommendations are based on immunological principles: one booster dose of vaccine in the case of mild exposure or 5 daily doses of vaccine followed by a booster dose twenty days later for severe exposures.

To Summarize:

Every person suspected of being exposed to rabies should be put under a physician's care immediately. There is no contraindication to treatment. For persons known or suspected of having been bitten, vaccine treatment should be begun immediately when:

1) The animal was apprehended and presented clinical signs of rabies.

2) The animal was killed and the brain found positive for rabies by microscopic examination.

3) The animal was killed and, though the brain was negative by microscopic examination, the animal was suspected of being rabid.

4) The person was exposed by a stray animal which escaped or could not be identified.

5) The suspected animal died within the 10 days observation period.

Other circumstances when treatment may be indicated:

1) The person is exposed to saliva or saliva contaminated materials. This is a situation for the physician to weigh and decide. He will have to examine the individual for breaks or abrasions of skin and take other factors into consideration, such as the presence of rabies in the area.

2) The person is exposed to milk of a rabid animal. The indications for treatment in this circumstance will be decided by the physician.

RECOMMENDATIONS FOR SPECIFIC ANTIRABIES PROPHYLAXIS†

Nature of Exposure	STATUS OF BITING ANIMAL (WHETHER VACCINATED OR NOT)		RECOMMENDED TREATMENT	
	At Exposure	During 10 Days Observation	Rabies Prevalent	Rabies Not Prevalent
I. No lesions, indirect contact	Healthy or rabid	Healthy or rabid	None	None
II. Licks: (1) unabraded skin	Rabid		None	None
(2) abraded skin scratches and unabraded or abraded mucosa	(a) Healthy	Clinical signs of rabies or proven rabid (laboratory)	Start vaccine at first signs of rabies in the *biting animal*	Start vaccine at first signs of rabies in the biting animal
	(b) Signs suggestive of° rabies	Healthy	Start vaccine immediately; stop at 5 days	None°°
	(c) Rabid, escaped, killed or unknown	Rabid	Start vaccine immediately	Start vaccine immediately
III. Bites: (1) mild exposure	(a) Healthy	Clinical signs of rabies or proven rabid (laboratory)	Serum immediately; Start vaccine when diagnosis *positive*	Start vaccine when diagnosis positive
	(b) Signs suggestive of rabies	Healthy	Serum and vaccine immediately; stop at 5 days	Serum and vaccine immediately; stop at 5 days
	(c) Rabid, escaped, killed or unknown		Start vaccine immediately	Vaccine immediately
	(d) wild wolf, jackal, fox, bat, skunk		Serum and vaccine immediately	Serum and vaccine immediately
(2) severe exposure (multiple, or face, hand, finger, or neck	(a) Healthy	Clinical signs of rabies or proven rabid (laboratory)	Serum immediately; start vaccine at first sign of rabies in the biting animal	Vaccine immediately
	(b) Signs suggestive° of rabies	Healthy	Serum and vaccine immediately; stop at 5 days	Serum and vaccine immediately; stop at 5 days
	(c) Rabid, escaped, killed or unknown	Rabid	Serum and vaccine immediately	Serum and vaccine immediately
	(d) Wild wolf, jackal, fox, bat, skunk		Serum and vaccine immediately	Serum and vaccine immediately

† Modified from Report of the WHO Expert Committee on Rabies 1966

° Suggestive in judgment of a Veterinarian

°° In areas where rabies is not prevalent the physician may recommend no treatment. Rabies should be considered prevalent in an area if one or more cases in animals have been reported within one year prior to the accident. This recommendation must be interpreted in the light of circumstances. A bite by a pet dog in an area of low prevalence would not require treatment whereas a bite by a wild animal such as a fox, skunk in the daytime, or bat would be an indication for treatment. Rats and mice do not transmit rabies. The extent and location of the bite should also be considered

Vaccination for Animals.

The WHO Committee considers prophylactic vaccination of dogs against rabies to be one of the most important weapons in rabies control and urges countries where infected areas exist to adopt vaccination programmes for their canine population.

The intramuscular administration of LEP Flury vaccine produced in developing chicken embryos[1] remains the prophylactic procedure of choice in dogs three months of age or older; it produces immunity lasting at least three years. The effectiveness of this vaccine was proved in controlled experiments when a dose of 3 ml. of a 33% suspension of infected chicken embryo was used; it is therefore felt that this amount of vaccine should be the minimum dose if an effective immunity of three years be desired. There is evidence from controlled experiments that HEP Flury vaccine produced in developing chicken embryos[1] protects dogs for 2 years. Other living-virus and inactivated-virus vaccines found to be antigenic by careful laboratory and field studies may be used for immunization of dogs.[2] However, annual revaccination of dogs inoculated with the latter vaccines is recommended, since only limited data are at present available indicating that they may confer immunity of longer duration.

Puppies less than three months old can be vaccinated safely with HEP Flury or Kelev chicken-embryo live-virus vaccine[1,3] or with any of the inactivated virus preparations, but not with LEP Flury vaccine[1] prepared in developing chicken embryos. Experimental evidence indicates that puppies less than three months old may not develop an immunological response to rabies vaccination as readily as older dogs; it is therefore recommended that a puppy inoculated with rabies vaccine before three months of age be revaccinated with any potent rabies vaccine as soon as possible after it reaches the age of three months.

After careful examination of the experimental and field data relating to the vaccination of dogs with LEP vaccine prepared in developing chicken embryos, the WHO Committee reaffirms the safety of this procedure and considers that such virus used for vaccination purposes does not constitute a danger for man or animal through transmission from saliva of the vaccinated dog. The Committee also found no evidence for the existence of the alleged street-virus carrier state in exposed dogs immunized with rabies vaccine.

Modified live-virus vaccines produced in a variety of tissue-culture systems for dogs are at present in the developmental stage and show promise of successful prophylactic use. In preliminary reports available to date, there is no information on duration of immunity beyond one year following experimental use of these vaccines. It is emphasized that adequately controlled experiments on longer duration of immunity in dogs are needed before consideration can be given to the use of these vaccines to replace established vaccines that induce immunity of known duration.

Handling of dogs and cats bitten by rabid animals

The WHO Committee strongly urges that non-vaccinated dogs, cats and other pets bitten by a known rabid animal should be immediately destroyed. If the owner be unwilling to have this done, the animal should be vaccinated and placed in strict isolation for four months or longer.

1. It should be pointed out that these vaccines are prepared from whole chicken embryos and should be distinguished from vaccines made from infected chicken-embryo tissue cultures.
2. The dosage of inactivated nervous-tissue vaccine for both puppies and adult dogs is 5 ml. of 20% tissue suspension or its equivalent.
3. A dosage of 3 ml. of 33% suspension for both HEP Flury and Kelev vaccines may be used in puppies.

If the animal has been previously vaccinated within three years with the LEP Flury strain of vaccine, within 2 years with the HEP strain of vaccine, or within one year with other vaccines, revaccination and restraint (leashing and confinement) for 30 days should be carried out.

It is important to develop means for the rapid routine investigation of persons and animals bitten by rabid animals so that immediate steps can be taken for the prevention of rabies in exposed persons and so that the bitten animal can be removed, thus breaking a potential link in the chain of transmission.

Recommendations for Rabies Control

A study of rabies control laws and methods in the United States shows that both are in a state of chaos. Only a few states have comprehensive laws. The enforcement of laws on the state level are in the hands of a variety of agencies and on the local level the variety is even greater. The following recommendations are a combination of the recommendations for rabies control made by the committee on Public Health Relations of the New York Academy of Medicine and The Expert Committee on Rabies of the World Health Organization*:

1) Efforts should be made to secure uniform national control measures against rabies. The Federal agencies concerned with rabies should draft a national plan for rabies eradication to be recommended to all health, livestock, sanitary and conservation authorities.

2) Prohibition of importation of dogs or cats to countries now free of rabies, or subjection of such imported animals to quarantine at port of entry for 6 months. Dogs originating in rabies free countries may be imported without quarantine provided the animals were isolated en route. Dogs originating in infected countries should be vaccinated within 12 months before departure and vaccinated as soon as possible after arrival.

3) The U.S.P.H.S. or the Bureau of Animal Industry, or both jointly, should be urged to formulate standard quarantine procedures covering the various situations that arise during an outbreak of rabies and to recommend these to the states and territories for adoption.

4) Transportation of dogs and other susceptible animals from one State to another by common carriers should be regulated by the Federal government in cooperation with the State agencies concerned. Permits for entry into a State should be contingent upon vaccination. Effective measures should be devised for the control of interstate transportation by private automobiles or other means not involving common carriers.

5) Health provisions governing the importation of all dogs and other susceptible animals from foreign countries should be promulgated and administered by the United States Public Health Service.

6) Rabies in any animal or human being should be made reportable in all States and local units of health jurisdiction and the figures published in public health reports.

7) Every State should require annual licensing of dogs. The license fee should be large enough to provide for efficient administration of the law, which requires an adequate force of control officers and veterinarians, as well as funds for vaccine and for the maintenance of pounds.

8) Local programs should be operated by health departments staffed with veterinarians.

9) Annual vaccination of dogs is recommended, particularly in urban areas. In these areas, the granting of a dog license should be made contingent upon vaccination. (Annual vaccination may be modified when longer effective vaccines are used.)

10) Provision of adequate facilities for diagnosis.

11) Dog pounds should be available for every unit of local health jurisdiction.

*The World Health Organization's Expert Committee on Rabies, Technical Report No. 321, 1966.

12) Vaccination of dogs with a single dose of either living or inactivated virus vaccine, repeated annually.

13) Mass vaccination of dogs free of charge.

14) Where feasible, a biting animal should be kept under observation for a period of ten days.

15) Dogs and cats bitten by a rabid animal should be destroyed. Alternatives to this are:

a) Strict isolation of the animal in a kennel for a period of 6 months;

b) If no previous vaccination has been given within a period of 12 months, vaccination and confinement in a kennel for 3 months;

c) If the animal has been previously vaccinated within 12 months, re-vaccination and restraint (leashing, secure confinement) for 30 days.

16) Elimination of stray animals.

17) Where restrictive measures only are depended upon, dogs should be restrained (leashing, secure confinement) for a minimum of 90 days from the date of the last known case of rabies. Where vaccination is also practiced, the period of restraint may be reduced to 30 days after vaccination.

18) Restraint of dogs while the control campaign is under way.

19) Domestic livestock exposed to rabies by bite will probably not propagate rabies and can be slaughtered for meat purposes within one week of the bite, or after six months. It should be noted that the greatest risk in dealing with exposed livestock is the danger encountered by people handling the live animal or the carcass, and not through the consumption of meat or milk from infected animals.

20) Reduction in number of wildlife species where these are a reservoir of the disease.

21) An educational program should be launched by appropriate health authorities to explain the necessity for control measures and especially the efficacy of the vaccines now approved by the Bureau of Animal Industry and the National Institute of Health.

Other Considerations.

The above recommendations leave a good deal of latitude for the local program. It does not mention the practice of muzzling. Muzzling is, of course, unnecessary if the above recommendations be carried out. But such a program is still distant, therefore, the effectiveness of muzzling must be understood. This can be gathered from experience in England which showed that rabies diminished extensively two years after a muzzling law was passed and enforced. But the law was repealed later due to misguided sympathy for dogs, and the disease reappeared. The law was again enforced, and in about two years rabies again disappeared.

The important basic factors determining the control of rabies are effective laws, enough finances and personnel. The problems of finances are more easily solved in large towns and cities than in rural areas. Charging a fee for vaccination could help finance rabies control projects, yet some administrators feel that such vaccinations should be given free just as immunization against smallpox and diphtheria in humans.

The tagging of vaccinated dogs is an effective practice in helping to identify the unvaccinated animals.

Handling of Dogs which have Bitten Persons or Animals.

Such dogs should not be killed unless it be clear that they have symptoms of rabies, and then only if they cannot be apprehended with safety. It is important to know definitely whether the dog is mad. If the dog can be found and kept under observation for ten days and no symptoms appear, the Pasteur treatment is not necessary for the bitten person. The dog should be turned over to the proper authority for observation and study. If no means be available for such isolation in a public quarter, then the sanitarian should see that proper isolation of the dog be effected at the home of the owner, and regular visits should be made by the sanitarian or health officer to ascertain the progress of the dogs. Animals killed early in the course of rabies may fail to show evidence of the disease, thus causing delay in diagnosis and fatal mistakes. If the animal be killed, the head should be sent to a laboratory without delay. If the laboratory be some distance away, the head should be iced.

If it becomes necessary to kill the animal, it should be shot through the heart and not through

Table 1

Rabies in the United States

Year	Dogs	Cattle	Horses	Sheep	Swine	Cats	Goats	Others	Man	Total
1938	8452	413	32	164	42	207	11	44	47	9412
1939	7386	358	36	17	38	269	10	172	30	8314
1940	6194	326	25	53	71	260	4	277	28	7238
1941	6648	418	39	68	159	294	9	212	30	7877
1942	6332	288	15	48	32	250	12	160	28	7165
1943	8515	349	35	45	60	316	19	310	41	9690
1944	9067	561	32	40	43	419	14	311	53	10540
1945	8505	487	46	11	30	466	10	373	35	9963
1946	8384	962	44	15	22	455	12	956	22	10872
1947	6949	766	40	15	20	393	9	728	26	8946
1948	6610	599	34	14	36	378	5	819	13	8508
1949	5237	639	24	22	54	413	6	1192	10	7597
1950	4979	948	33	48	85	428	5	1375	9	7910
1951	5194	821	34	35	53	480	4	1387	14	8022
1952	5266	919	38	19	31	501	7	1697	21	8499
1953	5688	1012	21	42	38	538	5	1479	14	8837
1954	4083	930	29	23	40	462	10	1697	8	7282
1955	2657	835	33	18	30	343	8	1915	5	5844
1956	2592	700	30	22	30	371	12	2079	10	5846
1957	1908	654	24	13	16	386	12	1989	6	5008
1958	1643	660	31	22	20	353	4	2075	6	4814
1959	1124	700	22	8	18	310	4	1925	6	4117
1960	697	563	36	17	16	288	4	1805	2	3428
1961	594	438	29	6	7	217	5	2174	3	3470
1962	565	*	*	*	*	232	*	**	2	3727
1963	573	459	44	5	14	217	6	2614	1	3933
1964	409	529	43	5	10	220	7	3560	1	4784
1965	412	536	67	5	12	289	5	3257	1	4584
1966	412	519	43	10	10	252	5	2946	1	4198
1967									0	

*Farm animals 614 total
**Foxes 1,038 Skunks 1,582 Bats 484 Other 153

the head. In amputation of the head, care should be taken not to injure the brain. The head should be amputated low enough to include part of the spinal cord. Rubber gloves should be used in this operation in order not to contaminate the hands with saliva or brain substance.

In packing the animal's head, it should first be placed in a tightly fitting metal container such as a one gallon friction top syrup can. This can should then be placed in another water-tight covered can which will allow sufficient space to add ice. No ice should be added to the can containing the head. If possible, both containers should be soldered to prevent leakage. A liquid solder is available which is satisfactory for this purpose. At the same time the head is shipped, a telegram should be sent to the laboratory informing it of the shipment. The package should be plainly marked and labelled "rush".

Authority, Responsibility and Regulations for Controlling Communicable Diseases

It is important for the sanitarian to understand in detail what the powers of his health officer are in the control of communicable diseases because he always acts for his health officer on official matters when investigating, consulting or carrying out regulatory measures relating to communicable diseases. Under such circumstances, the health officer delegates his authority to the sanitarian. The sanitarian must respect this responsibility of the health officer and must act with tact, circumspection, confidence and firmness. This is possible only by understanding the legal powers of the health officer.

In order to act effectively in the control of communicable diseases, the health officer or his agent should have the duty and the power:

1. To investigate as the circumstances may require for the purpose of verifying the diagnosis, ascertaining the source of the causative agent, disclosing unreported cases and revealing contacts. This includes the authority to enter and inspect any house, building, trailer, camp, train, airplane, bus, steamship or other watercraft, or any abode or permise.
2. To obtain laboratory specimans as may be necessary or desirable in confirmation of diagnosis, for ascertaining the source of the infection or for releasing cases or carriers.
3. To institute control measures and techniques, including concurrent and terminal disinfection, artificial immunization, placarding of premises, isolation and quarantine, the closing of schools and other places of public assembly, regulation of the transportation of patients and deceased persons, regulation of the conduct of funerals, reporting of diseases, issuance and revocation of permits for conducting any operation liable to cause the spread of diseases, requirements for all aspects of environmental sanitation, and the taking of any emergency measures necessary for the prevention and control of communicable diseases.
4. To give information concerning the disease and its prevention to the patient or a responsible member of his household, in order to prevent further spread of disease.

Burial, Removal, Transportation of the Dead

Administrative practice relating to deceased persons have become more and more a problem for the sanitarian as antiquated rules and regulations pertaining to this matter have been brought up-to-date and organized full-time health administration has spread to the less populous areas of the United States. The administrative control of dead bodies is carried on for several reasons, but mainly:

1) To control the spread of diseases which may have caused the death.
2) To detect unlawful causes of death and prevent the burial, removal or transporatation of such bodies.
3) To help keep an accurate account of the vital statistics of the community.

The following regulations were developed by the Engineering Section Project of the American Public Health Association:

Permits Required

No person shall allow the dead or embalmed body of any human being to remain unburied for a longer period than three days without special permission from the health officer, nor shall any

person allow the dead body of any human being to be exposed or retained for any time whatever to the peril or prejudice of the lives or health of any person.

No death certificate shall be valid unless signed by the coroner, or a regular licensed physician.

No person shall remove or dispose of any dead body of a human being by interment, cremation, or any other means without a permit from the health officer, nor in any manner other than in accordance with the rules of the health department.

No person in charge of any receptacle for the dead shall receive for burial or disposition any body without an accompanying certificate from the health officer.

Whenever any person shall die within an area of jurisdiction it shall be the duty of the physician who attended during his or her last illness, and the duty of the coroner, when the case comes within the discharge of his duties as prescribed by law, to furnish the health officer within 24 hours from the death of the patient a certificate setting forth as far as can be ascertained, the full name, occupation, sex, color, age, whether married or single, duration of last illness and the date of the death of such deceased person.

It shall be the duty of any undertaker, or any person having charge, before removing any corpse from the place where death occurred, to apply for and obtain a permit from the health department, which permit shall not be given before the filing with the health department, of a certificate signed by the attending physician or the coroner, stating the facts as called for in the blanks of the department, and said permit must be applied for by the undertaker, or other person having charge of the remains within 12 hours after the notification of death.

In case an inquest is necessary, it shall be the duty of the coroner to notify the department of health before permit is issued.

A transit permit and transit label issued by the health officer must accompany each dead body transported by a common carrier, vessel, car or public conveyance of any kind.

The transit permit shall state the date of issuance, the name, sex, race and age of the deceased, and the cause and date of death.

The transit permit shall also state the date and route of shipment, point of shipment and destination, the method or preparation of the body, and shall bear the signature of the undertaker.

The transit label shall state the date of issuance, the name of the deceased, the place and date of death, the name of the escort or consignee, the point of shipment and destination; and shall bear the signature and official title of the officer who issued the transit permit. The transit label shall be attached to the outer box or case.

Every sexton or person having charge of any tomb, vault, cemetery, crematory, or other receptacle for the dead, must register his name, address and nature of his duties with the health department and shall, on Monday of each week, make a report of all bodies buried according to the requirements of the health department. He shall not permit any dead body to be kept in any receiving vault over 72 hours, between May 1 and November 1, unless said body has been thoroughly embalmed and replaced in a strong, hermetically sealed case.

No person shall bury any body of a human being in any place other than a registered burial ground, without a specific permit from the health officer.

It shall be the duty of the undertaker in charge if a person dies of an infectious or contagious disease, if such body is to be sent out of the municipal limits, or out of the area of jurisdiction to make affidavit, if required, when the body is presented for shipment, that it is prepared according to the rules of the department of health.

All dead bodies brought into an area of jurisdiction from the outside must be buried under

permit issued by the health officer which the undertaker must obtain before removal for burial.

The undertaker in charge of bodies of persons dying from smallpox, diphtheria, cholera, plague, scarlet fever, typhus fever, or other pestilential diseases, shall at once cause the body to be disinfected, wrapped in a sheet wet with a solution of bichloride of mercury, (1 to 500), and placed immediately in a coffin the under surface of which must be lined with raw cotton and made absolutely tight, and not reopened. No body of a person who died of any infectious or contagious disease shall be placed in ice boxes or refrigerators, or frozen storage of any kind.

It shall be the duty of any person to report to the department of health the discovery or knowledge or the whereabouts of any dead human being, or any parts thereof, if there be any reason to believe that the death, or place of such body is not properly known.

In case of death from any pestilential disease, such as cerebral meningitis, smallpox, scarlet fever, relapsing fever, typhus fever, cholera, diphtheria, plague or measles, it shall be the duty of the person in charge of such deceased person to obtain a permit from the health officer, and to cause him or her to be buried within 24 hours; and the person in charge of the funeral of persons dying of any of said diseases must so conduct such funeral as to be absolutely private.* The remains of any person who died from contagious disease, such as diphtheria, diphtheritic croup, relapsing fever, scarlet fever, yellow fever, typhus fever, cholera, cerebro-spinal meningitis, or measles, shall not be admitted to any tomb or vault, public or private, without permission of the health officer, provided that a body which may have died of any of the above named diseases may be permanently entombed in a private vault, when said body is thoroughly embalmed and hermeti cally sealed in said tomb.

Requirements for Preparation of Body, Casket and Burial Place

The following requirements shall apply to the preparation of a body, a burial place, or a container for a dead body.

No undertaker or other person shall use any vehicle other than a hearse for the conveyance locally of the body of any person whose death was caused by any of the infectious or contagious diseases specified above, nor shall the body of such person be carried into any church, hall, or public place. The body of any person who died from any of said infectious or contagious diseases shall not be brought into any area of jurisdiction without special permit.

No person shall invite any other person to any funeral, or any services connected therewith, whose attendance is not necessary, to whom or through whom there is danger of contagion being communicated or spread. Whenever any person shall die from any of the contagious or infectious diseases, such as those listed above, the undertaker having charge of the preparation and interment of the remains shall be the only person authorized to insert public notice of death, and he shall state the cause of death in such notice for which he shall be held responsible.

The transportation by common carriers of bodies dead of any disease other than those stated below, shall be permitted under the following conditions.

The coffin or casket shall be encased in a strong outer box made of good sound lumber, not less than 7/8 of an inch thick. All joints shall be securely put together and the box tightly closed. Either the coffin or casket, or the outer box or case shall be water-tight. Every outside case holding any dead body offered for transportation by common carrier shall bear at least four handles,

*A modification of this aspect of the regulation has been accepted in some places to the effect that: When a funeral is held from place other than where the person dies, the health officer may, if the body has been embalmed and is permanently enclosed to his satisfaction, permit a public funeral. Bodies of persons whose deaths were caused by such disease must be buried as soon as practicable. Persons who have been placed in quarantine by the health officer on account of contact with the deceased before death, or for other reason, shall not be permitted to attend the funeral except under such conditions as the health officer shall specify to prevent the spread of infection.

and when over 5 feet 6 inches in length, shall bear six handles.

When the destination cannot be reached within 60 hours after death, all body orifices shall be closed with absorbent cotton and the body placed at once in a coffin or casket which shall be immediately closed and the coffin or casket shall be prepared as indicated in the above paragraph.

The transportation by common carrier of bodies dead of smallpox, plague, Asiatic cholera, typhus fever, diphtheria, (membranous croup, diphtheritic sore throat), scarlet fever, (scarlet rash, scarlatina), shall be permitted only under the following conditions:

All body orifices shall be closed with absorbent cotton, the body shall be enveloped in a sheet saturated with an effective disinfecting fluid and shall be placed at once in a coffin which shall be immediately and permanently closed. The coffin or casket shall be prepared as indicated above.

No dead bodies shall be disinterred for transportation by common carrier, or for removal to another cemetery in the same registration district, or in another district, but not requiring shipment by common carrier, without the previous consent of authorities having jurisdiction at the place of disinterment.

The undertaker shall make a request to disinter the body on a form provided for the purpose. This form shall provide for a statement of principal facts concerning the decedent, whether body is to be transported by common carrier or otherwise, final disposition of same, and approval of health officer. Upon receipt of such request the health officer shall issue a transit permit and transit label as required and the above provisions shall apply.

No disinterment shall be made except between sunrise and sunset.

Every grave must be at least 6 feet deep, and 4 feet below the grade or level of any adjacent street.

All overground vaults must be made of stone, granite, or marble, well cemented and substantially built.

It shall be the duty of any person having charge of articles used at funerals of persons who died of any infectious or contagious disease, to have the same property treated as directed by the health officer before being used again.

Vaults, mausoleums, cemeteries, crematories and all places of burial shall be maintained free of nuisance.

Mosquito breeding areas, such as urns and basins, shall be treated so as to prevent the growth of mosquito larvae in conformance with required provisions.

All water supply for drinking purposes provided at any burial place shall conform to the requirements for semipublic supplies, or for public supplies when a public supply is available to the burial place.

Drainage water and any sewage shall be disposed of in a manner conforming to provisions for drainage and sewage.

Refuse shall be disposed of in conformance with provisions for refuse disposal.

Interstate Control of Communicable Diseases

The administrative and technical procedures by which the responsibilities and powers to control communicable diseases are translated into practice are discussed throughout this book. Most of the provisions will pertain to state and local public health administrative practice. In order to broaden the sanitarians understanding in these matters, some of the more general and pertinent provisions for interstate control of communicable disease by which the United States Public Health

Service operates will be given below:

Measure in the event of Inadequate Local Control. Whenever the Surgeon General determines that the measures taken by health authorities of any State or possession (including political subdivisions thereof) are insufficient to prevent the spread of any of the communicable diseases from such State or possession to any other State or possession, he may take such measures to prevent such spread of the diseases as he deems reasonably necessary, including inspection, fumigation, disinfection, sanitation, pest extermination, and destruction of animals or articles believed to be sources of infection.

Restriction on Travel of Persons with Communicable Diseases. A person who has a communicable disease in the communicable period shall not travel from one State or possession to another without a permit from the health officer of the state, possession, or locality of destination, if such permit is required under the law applicable to the place of destination. Stop-overs other than those necessary for transportation connections shall be considered as places of destination.

Certain Communicable Diseases; Special Requirements. The following provisions are applicable with respect to any person who is in the communicable period of cholera, plague, smallpox, typhus or yellow fever, or who, having been exposed to any such disease, is in the incubation period thereof:

(a) Requirements relating to travelers. 1. No such person shall travel from one State or possession to another, or on a conveyance engaged in interstate traffic, without a written permit of the Surgeon General or his authorized representative. 2. Application for a permit may be made directly to the Surgeon General or to his representative authorized to issue permits. 3. Upon receipt of an application, the Surgeon General or his authorized representative shall, taking into consideration the risk of introduction, transmission, or spread of the disease from one State or possession to another, reject it, or issue a permit which may be conditioned upon compliance with such precautionary measures as he shall prescribe. 4. A person to whom a permit has been issued shall retain it in his possession throughout the course of his authorized travel and comply with all conditions prescribed therein, including presentation of the permit to the operators of conveyance as required by its terms.

(b) Requirements relating to operation of conveyances. 1. The operator of any conveyance engaged in interstate traffic shall not knowingly accept for transportation any person who fails to present a permit as required or transport any person in violation of conditions prescribed in his permit. 2. Whenever a person is transported on a conveyance engaged in interstate traffic, the operator thereof shall take such measures to prevent the spread of the disease, including submission of the conveyance to inspection, disinfection and the like, as an officer of the Public Health Service designated by the Surgeon General for such purposes deems reasonably necessary and directs.

Report of Disease. The master of any vessel or person in charge of any conveyance engaged in interstate traffic, on which a case or suspected case of a communicable disease develops shall, as soon as practicable, notify the local health authority at the next port of call, station, or stop, and shall take such measures to prevent the spread of the disease as the local health authority directs.

Psittacine Birds. (a) The term psittacine birds shall include all birds commonly known as parrots, amazons, Mexican double heads, parakeets, African grays, cockatoos, macaws, love birds, lories, lorikeets, and all other birds of the psittacine family. (b) A person shall not offer for transportation, or transport, in interstate traffic any psittacine bird unless:

1. The shipment is destined to a zoological park or research institute and the shipment is accompanied by a permit from the State Health Department of the State of destination (where required), or

2. The shipment does not exceed two birds, the birds are accompanied by the owner, have been in his possession for the preceding two years, have not had contact with other psittacine birds during that period, will be transported immediately to the owner's private residence and retained there as household pets, and are accompanied by a permit from the State Health Department of the State of destination (where required). Psittacine bird regulations have recently been rescinded.

Garbage. (a) A person shall not transport, receive, or cause to be transported or received, garbage in interstate traffic and feed such garbage to swine unless, prior to the feeding, such garbage has received minimum heat treatment. (b) A person transporting garbage in interstate traffic shall not make, or agree to make, delivery thereof to any person with knowledge of the intent or customary practice of such person to feed to swine garbage which has not been subjected to minimum heat treatment.

Shellfish. A person shall not offer for transportation, or transport, in interstate traffic any shellfish handled or stored in such an insanitary manner, or grown in an area so contaminated, as to render such shellfish likely to become agents in, and their transportation likely to contribute to, the spread of communicable disease from one State or possession to another.

Sanitation of Water Boats. No vessel engaged in interstate traffic shall obtain water for drinking and culinary purposes from any water boat unless the tanks, piping, and other appurtenances used by the water boat in the loading, transportation, and delivery of such drinking and culinary water, have been approved by the Surgeon General.

Protection of Pier Water System. No vessel engaged in interstate traffic shall make a connection between its non-potable water system and any pier potable water system unless provisions are made to prevent backflow from the vessel to the pier.

Vessels: Sanitation Facilities and Conditions. The sanitation facilities and the sanitary conditions on vessels engaged in interstate traffic shall comply with the requirements for potable water systems, provided that no major structural change will be required on existing vessels.

Potable Water: Source and Use: Water for Drinking and Culinary Purposes: General Requirement. Only potable water shall be provided for drinking and culinary purposes by any operator of a conveyance engaged in interstate traffic, except where provisions are made for heating water to at least 170°F. before discharging from the heater. Such water either shall have been obtained from watering points approved by the Surgeon General, or shall have been subjected to treatment approved by the Surgeon General.

Approval of Watering Points. (a) The Surgeon General shall approve any watering point if (1) the water supply thereat meets the standards prescribed in the Drinking Water Standards of the U. S. P. H. S. and (2) the methods of and facilities for delivery of such water to the conveyance and the sanitary conditions surrounding such delivery prevent the introduction, transmission, or spread of communicable diseases. (b) The Surgeon General may base his approval or disapproval of a watering point upon investigations made by representatives of State Departments of Health or of the health authorities of contiguous foreign nations. (c) If a watering point has not been approved, the Surgeon General may permit its temporary use under such conditions as, in his judgment, are necessary to prevent the introduction, transmission, or spread of communicable diseases. (d) Upon request of the Surgeon General, operators of conveyances shall provide information as to watering points used by them.

Approval of Treatment. (a) The treatment of water shall be approved by the Surgeon General if the apparatus used is of such design and is so operated as to be capable of producing, and in fact does produce, potable water. (b) The Surgeon General may base his approval or disapproval of treatment of water upon investigations made by representatives of State departments of Health or of the health authorities of contiguous foreign nations. (c) Overboard water treated on vessels shall be from areas relatively free of contamination and pollution.

Storage of Water Prior to Treatment. The following requirements with respect to the storage of water on vessels prior to treatment must be met in order to obtain approval of treatment facilities. (a) The tank, whether independent or formed by the skin of the ship, deck, tank top, or partitions common with other tanks, shall be free of apparent leakage. (b) No sanitary drain shall pass through the tank. (c) The tank shall be adequately protected against both the backflow and discharge into it of bilge or highly contaminated water.

Water in Galleys and Medical Care Spaces. (a) Potable water, hot and cold, shall be available in the galley and pantry except that, when potable water storage is inadequate, non-potable

water may be piped to the galley for deck washing and in connection with garbage disposal. Any tap discharging non-potable water which is installed for deck washing purposes shall not be more than 18 inches above the deck and shall be distinctly marked "For deck washing only". (b) In the case of existing vessels on which heat treated wash water has been used for washing of utensils prior to the effective date of the regulations in this part, such water may continue to be so used provided controls are employed to insure the heating of all water to at least 170°F. before discharge from the heater. (c) Potable water, hot and cold, shall be available in medical care spaces for hand-washing and for medical care purposes excluding hydrotherapy.

Water for Making Ice. Only potable water shall be piped into a freezer for making ice for drinking and culinary purposes.

Drinking Fountains and Coolers; Ice; Constant Temperature Bottles. (a) Drinking fountains and coolers shall be constructed of impervious, non-oxidizing material, and shall be so designed and constructed as to be easily cleaned and protected against backflow. The jet of a drinking fountain shall be slanting and the orifice of the jet shall be protected by a guard in such a manner as to prevent contamination thereof by droppings from the mouth or by splashing from the basin. The orifice of such a jet shall be located at least 1/2 inch above the rim of the basin. (b) Ice shall not be permitted to come in contact with water in coolers or constant temperature bottles. (c) Constant temperature bottles and other containers used for storing or dispensing potable water shall be kept clean at all times and shall be subjected to effective bactericidal treatment after each occupancy of the space served and at intervals not exceeding one week.

Wash Water. (a) Wash water means water suitable for domestic uses other than for drinking and culinary purposes, and medical care purposes excluding hydrotherapy. (b) Where wash water systems installed on vessels do not comply with the requirements of a potable water system, they shall be constructed so as to minimize the possibility of the water therein being contaminated. The storage tanks shall comply with the above requirements and the distribution system shall not be cross connected to a system carrying water of a lower sanitary quality. All faucets shall be labeled "Unfit for drinking".

Swimming Pools. (a) Fill and draw swimming pools shall not be installed or used. (b) Swimming pools of the recirculation type shall be equipped as to provide complete circulation, replacement, and filtration of the water in the pool every six hours or less. Suitable means of chlorination and, if necessary, other treatment of the water shall be provided to maintain the residual chlorine in the pool water at not less than 0.4 part per million and the pH not less than 7.0. (c) Flowing-through type of salt water pools shall be so operated that complete circulation and replacement of the water in the pool will be effected every six hours or less. The water delivery pipe to the pool shall be independent of all other pipes and shall originate at a point where maximum flushing of the pump and pipe line is effected after leaving polluted waters.

Toilets and Lavatories. Toilet and lavatory equipment and spaces shall be maintained in a clean condition.

Discharges of Wastes. Vessels operating on fresh water lakes or rivers shall not discharge sewage, or ballast or bilge water, within such areas adjacent to domestic water intakes as are designated by the Surgeon General.

Insect Control. Vessels shall be maintained free of infestation by flies, mosquitoes, fleas, lice, and other insects known to be vectors in the transmission of communicable diseases, through the use of screening, insecticides, and other generally accepted methods of insect control.

Rodent Control. Vessels shall be maintained free of rodent infestation through use of traps, poisons, and other generally accepted methods of rodent control.

Land and Air Conveyances: Servicing Areas; Applicability. Land and air conveyance engaged in interstate traffic shall use only such servicing areas within the United States as have been approved by the Surgeon General as being in compliance with the requirements prescribed.

Inspection and Approval. The Surgeon General may inspect any such areas to determine whether

they shall be approved. He may base his approval or disapproval on investigations made by representatives of State departments of health.

Submittal of Construction Plans. Plans for construction or major reconstruction of sanitation facilities at servicing areas shall be submitted to the Surgeon General for review of the conformity of the proposed facilities with these requirements.

General Requirements. Servicing areas shall be provided with all necessary sanitary facilities so operated and maintained as to prevent the spread of communicable diseases.

Platforms and Drainage. Platforms shall be of impervious material and kept in good repair. Platforms and ground surfaces shall be adequately drained.

Watering Equipment; General Requirements. All servicing area piping systems, hydrants, taps, faucets, hoses, buckets, and other appurtenances necessary for delivery of drinking and culinary water to a conveyance shall be designed, constructed, maintained and operated in such a manner as to prevent contamination of the water.

Watering Equipment; Dual Systems. In the case of existing installations where water not approved for use as drinking and culinary water is available for other purposes, there shall be no physical connection with the drinking water system, and the outlets of the non-approved systems shall be provided with fittings unsuited for drinking water hose connections. Such outlets shall be posted with permanent signs warning that the water is unfit for drinking. Dual water systems will not be permitted in new installations.

Watering Equipment; Cleaning and Bactericidal Treatment. Facilities shall be provided for cleaning and bactericidal treatment of all systems and appurtenances used in the transportation, storage, or handling of water or ice which may be used for drinking and culinary purposes.

Watering Equipment; Ice. If bulk ice is used for the cooling of drinking water or other beverages, or for food preservation purposes, equipment constructed so as not to become a factor in the transmission of communicable diseases shall be provided for the storage, washing, handling, and delivery to conveyances of such bulk ice, and such equipment shall be used for no other purposes.

Employee Conveniences. (a) There shall be adequate toilet, washroom, locker, and other essential sanitary facilities readily accessible for use of employees adjacent to places or areas where land and air conveyances are serviced, maintained, and cleaned. These facilities shall be maintained in a clean and sanitary condition at all times. (b) In the case of diners not in a train but with a crew on board, adequate toilet facilities shall be available to the crew within a reasonable distance but not exceeding 500 feet of such diners. (c) Drinking fountains and coolers shall be constructed of impervious, non-oxidizing material, and shall be so designed and constructed as to be easily cleaned and protected against backflow.

Disposal of Body Discharges. At servicing areas or stations where land and air conveyances are occupied by passengers, the operations shall be so conducted as to avoid fecal contamination of these areas. This shall be accomplished:

(a) By locking toilet rooms, or

(b) By the use of flexible watertight connections between toilet hoppers and sewer lines, or

(c) By the use of soil cans or chemical toilets which shall be constructed of durable, watertight, rust-resisting material designed to permit ready cleaning, and in the case of soil cans, designed to fit the toilet hopper outlet.

Where soil cans or chemical toilets are used, the contents thereof shall be disposed of thru sewers or other recognized methods for sanitary disposal of fecal material and the cans shall be thoroughly cleaned before being returned to use. Equipment for cleaning such containers shall be so designed as to prevent backflow into the water line, and such equipment shall be used for no other purpose.

All persons handling soil cans or chemical toilets shall be required to wash their hands

thoroughly with soap and warm water before engaging in any work connected with the handling water, food or ice.

Garbage Disposal. (a) Watertight, readily cleanable, non-absorbent containers with close-fitting covers shall be used to receive and store garbage. (b) Can washing and draining facilities shall be provided. (c) Garbage cans shall be emptied daily and shall be thoroughly washed before being returned for use.

Land and Air Conveyances: Equipment and Operation; Applicability. The sanitary equipment and facilities on land and air conveyances engaged in interstate traffic and the use of such equipment and facilities shall comply with these requirements.

Submittal of Construction Plans. Plans for the construction or major reconstruction of sanitary equipment and facilities on such conveyances shall be submitted to the Surgeon General for review of the conformity of such plans with these requirements.

Water System; Constant Temperature Bottles. (a) The water system, either of the pressure or gravity type, shall be complete and closed from the filling ends to the discharge taps. The water system shall be protected against backflow. (b) Filling pipes or connections through which water tanks are supplied shall be provided on both sides of all new railway conveyances and on existing conveyances when they undergo heavy repairs. All filling connections shall be easily cleanable and so located and protected as to minimize the hazard of contamination of the water supply. (c) On all new or reconstructed conveyances, water coolers shall be an integral part of the closed system. (d) Water filters if used on dining cars and other conveyances will be permitted only if they are so operated and maintained at all times as to prevent contamination of the water. (e) Constant temperature bottles and other containers used for storing or dispensing potable water shall be kept clean at all times and shall be subjected to effective bactericidal treatment as often as may be necessary to prevent the contamination of water so stored and dispensed.

Drinking utensils and Toilet Articles. (a) No cup, glass, or other drinking utensil which may be used by more than one person shall be provided on any conveyance unless such cup, glass, or drinking utensil shall have been thoroughly cleaned and subjected to effective bactericidal treatment after each individual use. (b) Towels, combs, or brushes for common use shall not be provided.

Toilet and Lavatory Facilities. (a) Where toilet and lavatory facilities are provided on conveyances, they shall be so designed as to permit ready cleaning. On conveyances not equipped with retention facilities, toilet hoppers shall be of such design and so located as to prevent spattering of water filling pipes and hydrants, and to permit the attachment of suitable soil cans or flexible sewer connections. (b) Separate facilities for brushing teeth shall be provided in washrooms of all conveyances having sleeping accommodations.

Railway conveyances; Food Handling Facilities. (a) Both kitchens and pantries of cars hereafter constructed or reconstructed shall be equipped with double sinks, one of which shall be of sufficient size and depth to permit complete immersion of a basket of dishes during bactericidal treatment; in the pantry a dishwashing machine may be substituted for the double sinks. If chemicals are used for bactericidal treatment, 3-compartment sinks shall be provided. (b) A sink shall be provided for washing and handling cracked ice used in food or drink and shall be used for no other purpose. (c) Toilet and lavatory facilities for the exclusive use of the dining car employees shall be provided on each train. (d) Wherever toilet and lavatory facilities required by paragraph (c) of this section are not on the dining car, a lavatory shall be provided on the dining car for the use of the employees. The lavatory shall be conveniently located and used only for the purpose for which it is installed.

Cleanliness of Conveyance. Conveyances while in transit shall be kept clean and free of flies and mosquitoes. A conveyance which becomes infected with vermin shall be placed out of service until such time as it shall have been effectively treated for the destruction of the vermin.

Ice. Ice shall not be permitted to come in contact with water in coolers or constant temperature bottles.

Land Conveyances; Discharge of Wastes. (a) There shall be no discharge of excrement, garbage, waste water, or other polluting material from any land conveyance while such conveyance is passing over areas designated by the Surgeon General. (b) Toilets shall be kept locked at all times when a conveyance is at a station stop unless adequate watertight containers are used to receive the discharges.

Air Conveyances; Discharge of Wastes. Excrement, garbage, or similar matter shall not be discharged from any air conveyance in flight over land areas or waters subject to the control of the United States.

Land and Air Conveyances and Vessels: Food: Applicability. All conveyances engaged in interstate traffic shall comply with these requirements.

Inspection. The Surgeon General may inspect such conveyances to determine compliance with these requirements.

General Requirements. All food and drink served on conveyances shall be clean, wholesome, and free from spoilage, and shall be prepared, stored, handled, and served in accordance with these requirements.

Source of Food and Drink; Identification and Inspection. (a) Operators of conveyances shall identify, when requested by the surgeon General, the vendors, distributors, or dealers from whom they have acquired or are acquiring their food supply including milk, milk products, frozen desserts, bottled water, sandwiches, box lunches, and shellfish. (b) The Surgeon General may inspect any source of such food supply in order to determine whether the requirements of the regulations are being met, and may utilize the results of inspections of such sources made by representatives of State health departments or of the health authorities of contiguous foreign nations.

Milk, Milk Products, and Shellfish. Milk, milk products, and shellfish served on conveyances shall conform to the following requirements:

(a) No milk shall be served or sold on any conveyance unless such milk is pasteurized and is obtained from a source of supply approved by the Surgeon General. The Surgeon General shall approve any source of supply at or from which milk is produced, processed, and distributed so as to prevent the introduction, transmission, or spread of communicable diseases. If a source of milk supply has not been approved, the Surgeon General may permit its temporary use under such conditions as in his judgment, are necessary to prevent the introduction, transmission, or spread of communicable diseases.

(b) Milk containers shall be plainly labeled to show the contents, the grade, the word "pasteurized", and the identity of the plant at which the contents were packaged.

(c) All milk products, including reconstituted milk, buttermilk, milk beverages, frozen desserts, butter, and cheese shall be pasteurized or manufactured from milk or milk products that have been pasteurized or subjected to equivalent heat treatment.

(d) Containers or packages of milk products shall be plainly labeled to show the contents, the word "pasteurized" if the contents have been pasteurized, or such other term as would indicate that the contents have been subjected to heat treatment equivalent to pasteurization, and the identity of the plant at which the contents were packaged.

(e) Milk, buttermilk, and milk beverages shall be served in or from the original individual containers in which received from the distributor, or from a bulk container equipped with a dispensing device or designed, constructed, installed, and maintained as to prevent the transmission of communicable diseases.[1]

(f) Shellfish purchased for consumption on any conveyance shall originate from a dealer currently listed by the Public Health Service as holding an unexpired and unrevoked certificate issued by a State authority.[2]

1. For suggested specifications, see Ordinance and Code Regulating Eating and Drinking Establishments (1943), Public Health Bulletin No. 280.

2. The Public Health Service issues a list of such dealers bi-weekly for the information of State health authorities and all others concerned.

(g) Shucked shellfish shall be purchased in the containers in which they are placed at the shucking plant and shall be kept therein until used. The State abbreviation and the certificate number of the packer shall be permanently recorded on the containers.

Storage of Perishables. All perishable food or drink shall be kept at or below 50°F., except when being prepared or kept hot for serving.

Ice; Source and Handling. All ice coming in contact with food or drink and not manufactured on the conveyance shall be obtained from sources approved by competent health authorities and shall be stored and handled in such manner as to avoid contamination. Such ice shall be thoroughly washed with potable water on the conveyance except in the case of ice cubes which are delivered to the conveyance in sealed containers.

Places Where Food is Prepared, Served, or Stored; Construction, Maintenance, and Use. (a) All kitchens, galleys, pantries, and other places where food is prepared, served, or stored shall be adequately lighted and ventilated, provided, however, that ventilation of cold storage rooms shall not be required. All such places where food is prepared, served, or stored shall be so constructed and maintained as to be clean and free from flies, rodents, and other vermin. (b) Such places shall not be used for sleeping or living quarters. (c) Water of satisfactory sanitary quality, under head or pressure, and adequate in amount and temperature, shall be easily accessible to all rooms in which food is prepared and utensils are cleaned. (d) All plumbing shall be so designed, installed and maintained as to prevent contamination of the water supply, food and food utensils.

Utensils and Equipment. (a) All utensils and working surfaces used in connection with the preparation, storage, and serving of food or beverages, and the cleaning of food utensils, shall be so constructed as to be easily cleaned and self-draining and shall be maintained in good repair. Adequate facilities shall be provided for the cleaning and bactericidal treatment of all multi-use eating and drinking utensils and equipment used in the preparation of food and beverages. An indicating thermometer, suitably located, shall be provided to permit the determination of the hot water temperature when and where hot water is used as the bactericidal agent. (b) All multi-use eating and drinking utensils shall be thoroughly cleaned in warm water and subjected to an effective bactericidal treatment after each use. All other utensils that come in contact with food and drink shall be similarly treated immediately following the day's operation. All equipment shall be kept clean. (c) After bactericidal treatment, utensils shall be stored and handled in such manner as to prevent contamination before reuse.

Refrigeration Equipment. Each refrigerator shall be equipped with a thermometer located in the warmest portion thereof. Waste water drains from ice boxes, refrigerating equipment, and refrigerated spaces shall be so installed as to prevent backflow of contaminating liquids.

Garbage Equipment and Disposition. Water-tight, readily cleanable, non-absorbent containers with close-fitting covers shall be used to receive and store garbage. Garbage and refuse shall be disposed of as frequently as is necessary and practicable.

Toilet and Lavatory Facilities for Use of Food-handling Employees. (a) Toilet and lavatory facilities of suitable design and construction shall be provided for use of food-handling employees. Except on air conveyances, toilet rooms which open directly into rooms where food is prepared, stored, or served, or in which food utensils are handled or stored shall have tight-fitting self-closing doors. (b) Signs directing food-handling employees to wash their hands after each use of toilet facilities shall be posted so as to be readily observable by such employees. Hand washing facilities shall include hot running water, soap, and towels for individual use. (c) All toilet rooms shall be maintained in a clean condition.

Food-handling Operations. All food-handling operations shall be accomplished so as to minimize the possibility of contaminating food, drink, or utensils.

The hands of all persons shall be kept clean while engaged in handling food, drink, utensils, or equipment.

Health of Persons Handling Food. Any person who is known or suspected to be in a communicable period or a carrier of any communicable disease shall not be permitted to engage in the preparation, handling, or serving of water, other beverages, or food.

Any person known or suspected to be suffering from gastrointestinal disturbance or who has on the exposed portion of the body an open lesion or an infected wound shall not be permitted to engage in the preparation, handling, or serving of food or beverages.

Certification Following Inspections: Issuance and Posting of Certificates. The Surgeon General may issue certificates based upon inspections provided for above. Such certificates shall be prominently posted on conveyance.

Drinking Water Standards: (See "Public Health Service Drinking Water Standards" quoted in chapters on Public Water Supplies and Bacteriology of Water.)

WORM PARASITES

Diseases due to worm parasites are extant throughout the world, especially in the tropics where they are the cause of a major health problem. There are a number of parasitic worm diseases found in North America which cause much debility and economic loss. Worm infections among the children of the United States are greater than is generally recognized. To a very large degree, worm infection is due to unsanitary conditions and poor personal hygiene. For the worms most prevalent in the United States, the family is the unit of infection with children playing the major role in transmission, although schools, mental institutions and orphanages may also serve as units of infection. The sanitarian should know the life history of these worms because the methods of preventing the diseases caused by them are in the province of environmental sanitation and health education.

The human parasitic worms (helminths) are divided into two large groups, namely; the round worms (Nemathelminths) and the flat worms (Platyhelminths). The class Nematoda among the round worms are important to man. The Nematoda in North America with which the sanitarian should be acquainted are:

1) Hookworm (Necator americanus)
2) Large round worm (Ascaris lumbricoides)
3) Pin worm (Enterobius vermicularis)
4) Whip worm (Trichuris trichiura)
5) Trichinella spiralis
6) Wuchereria bancrofti.

There are two classes of flat worms which are important to man, namely; the class Cestoda and the class Trematoda. The latter is not important to North America, but the Cestoda to which belong the tapeworms, are of great import. The cestodes with which the sanitarian should be acquainted are:

1) Beef tapeworm (Taenia saginata)
2) Pork tape worm (Taenia solium)
3) Dwarf tapeworm (Hymenolepis nana or Taenia nana)
4) Rat tapeworm (Hymenolepis diminuta or Taenia diminuta)
5) Dog tapeworm (Dipylidium caninum or Taenia caninum)
6) Echinococcus granulosus or Taenia echinococcus
7) Fish tapeworm (Diphyllobothrium latum).

The eggs of all these parasites are microscopic in size. The adults may range in size from over 30 feet long in case of the fish tapeworm, 10 m. m. in case of the dwarf tapeworm.

Some of these parasites have several hosts, namely; a definitive host and an intermediate. The definitive host is the one in which the adult form of the parasite develops or sexual reproduction takes place, and the intermediate host is the one in which the larval form of the parasite develops, and where no sexual reproduction takes place.

The life histories of the round worm parasites are as follows:

Necator americanus or hookworm is a very prevalent disease producing worm in southeastern United States. Its prevalence extends from Virginia to Texas, including Kentucky, Tennessee, North and South Carolina, Georgia, Florida, Alabama, Mississippi, Arkansas and Louisiana. It is found in areas where the soil is moist and sandy or of sandy loam and where the weather is warm, preferring temperatures between 75°F and 85°F. Drying quickly kills the larvae and even the eggs. The adult worm is a pinkish, grayish color, threadlike in form, and is between 8 and 10 m. m. long. It prefers to live in the upper part of the small intestines where it attaches itself to the lining of the intestine and sucks blood. Each worm consumes about half c. c. of blood daily. Thus a thousand worms would probably consume about a pint of blood daily. It has been estimated that it takes about 300 such parasites to produce symptoms in any individual. The symptoms it produces are

intestinal disturbances, anemia, debility, toxemia in pregnant mothers, and pneumonia among children. It may be the cause of death and has certainly helped to aggravate the already poor rural economy among southern farmers. The growth of infected children may be stunted and their mentality retarded.

The female adult produces eight to ten thousand eggs daily, which are found dispersed thruout the feces. When the feces reaches the ground, the eggs hatch in one to several days depending on the temperature. The larvae seek cool shady places on the ground and burrow into the surface soil for protection. They moult twice while free living. At the end of the second moult they are about 1/2 m. m. long. This is the infective stage. This stage is very sensitive to drying and extreme temperature. They keep out of the sunlight by hiding under blades of grass or in tiny burrows. Here they lie in wait for their victim, a barefoot child usually. When they get on the skin they are able to penetrate in several minutes, and they produce an itchy area on the skin called "ground itch". But if they do not immediately find a host, they may live 4 to 8 weeks in shaded, moist ground in tropical country, and even longer in the cooler environment of the subtropics. After penetrating the skin, they get into the blood stream, where they are carried to the large veins toward the heart, from the heart to the lungs where the vessels are so small that they are unable to get through and be carried back to the heart; therefore, they penetrate through the lung tissue into the air spaces of the lung where they set up inflammatory processes; then, they crawl up to the throat and are swallowed. They finally land in the upper small intestines. During their migratory sojourn, they go through their third moult. It takes about a week for the larvae to make their journey from the skin to the intestines. When they reach the intestines, they go through their last moult. A month after entering the body they reach maturity and begin to produce eggs. Hookworm disease is called ancylostomiasis.

Without treatment most worms will disappear within six months from the intestines; some will take as long as 7 years or more. People may become infected by swallowing the larval form, but this is a very unusual way of becoming infected. Surveys show that Negroes contract this disease only one fourth as often as Whites. The author has made surveys where the White children were found with almost 100% infection and the Negro children with only around 5 to 8%. This difference has been attributed to racial immunity, but it is believed by some investigators that the difference is due to better hygienic habits among the Negroes.

When the Rochefeller Foundation started its work in hookworm control in Southern United States (1909), it found an incidence of about 37% infection among the population. Surveys made between 1930 and 1938, revealed about 12% infection, In 1942, 40 to 50% of the rural population in South Georgia were found positive for hookworms. More recent unpublished surveys show that although the areas of hookworm infection have contracted considerably in the past 40 years, there are still rural areas in the South where the rate of hookworm positive children is as still quite great. The worm load per individual is also lighter today. Only 10 to 15% of the positives show demonstrable signs of the disease. It is a disease which we absolutely know how to control. The control can be quickly effected by adequate facilities for excreta disposal and an adequate diet. Hookworm is primarily a disease of the impovished white people in the rural areas of the South. The rate of infection is higher as the size of the family unit increases. The manifestation of symptoms becomes more severe as the nutritional status becomes poorer. The incidence of infection is greatest in the age group 5 to 19 years, being about 1/2 as great in the pre-school and adult age groups.

Another form of hookworm disease which has recently been increasing and spreading in the South is called creeping eruption, and is caused by the species Ancylostoma braziliense, the cat and dog hookworm. The larvae of this species penetrate the skin but are unable to complete the same cycle as Necator americanus. The worm creeps along under the surface of the skin producing much irritation and discomfort. The adult worms are found in the intestines of cats and dogs. These animals defecate on the soil frequented by children or workmen whose skin may come in contact with the larvae hatched from the eggs in the animal feces. The larvae penetrate the skin and begin their creeping. Prevention programs are very difficult and consist of: 1) Preventing dogs and cats from defecating in places where children and workmen frequent, and keeping these animals from the beaches; 2) treatment of household pets and keeping stray animals out of circulation; 3) applying larvicidal chemicals to the soil.

The larvicidal chemicals which have been found most effective are sodium borate, polybor 3,

and calcium cyanimide. They can be used against soil contamination by other types of hookworm. Sodium borate is used at the rate of 10 lbs. per 100 square feet. The use of these chemicals should be limited to small areas such as around homes, kennels, and beaches.

Ascaris lumbricoides. - This worm is found over our whole country, especially among children. It is the largest of our round worm parasites, being 25 to 40 c. m. long. It looks like an earthworm and has a yellowish white to light brown color. It lives mostly in the small intestines but may wander about, and is a prolific producer of eggs: approximating 200, 000 daily. The eggs are expelled with the feces. Fresh eggs are not infective. It takes about a month for the larvae to develop inside the egg at optimum temperature of 30°C. Such an egg is known as "embryonated". The eggs like warmth, moisture and air. Drying in hot weather kills the egg, but it may remain viable for a long time when not subjected to too much heat and drying. Infection is produced by the swallowing of "embryonated" eggs. When the eggs get into the small intestine, the shell is broken and the larvae penetrate the intestinal wall, from which they enter the blood stream. From then on, the course of the larvae is the same as that of the hookworm larvae. In the lungs, the larvae moult after 5 or 6 days and again around the 10th day. By this time, they have grown to the length of 1 to 2 m. m., and then like the hookworm larvae, they are swallowed and reach the intestines. After 8 to 10 weeks in the intestines, they grow into adults and the female begins to produce eggs. The life span of the adult is about one year. Like the hookworm, they may produce lung symptoms, but may also get into the appendix or bile duct, producing obstruction and inflammation. The eggs get into the mouth by way of dirty hands and poor personal hygiene. Control measures include sanitary excreta facilities and teaching of good personal hygiene.

Enterobius vermicularis or pin-worm, or seat-worm, or thread-worm is a distressing infestation to have, because the adult worms like to wander out of the rectum to lay their eggs around the anal region. Here they cause a good deal of irritation and itching, and cause children to become nervous and irritable. In female children they may even wander into the vagina and set up a distressing itch. The eggs contaminate the children's clothing and get back into the mouth by way of unclean hands. The adult worm usually lives around the junction of the large and small intestine where it attaches itself to the intestinal wall. The adult female wanders a good deal and usually chooses to migrate out of the rectum to lay its eggs. The adults are 8 to 13 m. m. long. After the eggs reach the outside world, it takes about 36 hours for them to become infective. When the infective eggs are swallowed, they pass into the upper small intestine and hatch. Then they start migrating down toward the lower part of the intestines. They go through two moults and become mature by the time they reach the lower small intestine. Sometimes they get into the appendix and set up irritation there. The life cycle is simple and takes about four weeks.

Trichuris trichiura, or whipworm. This worm is 30 to 50 m. m. long and thread-like in the adult stage. Its life cycle is as simple as that of the pin-worm. The adult likes to live in the vicinity of the appendix. They lay eggs which leave the body with the human feces. Through poor personal hygiene the eggs get on the hands and are swallowed. But the eggs, when outside of the body may remain infective as long as several years, because the shell is resistant to the elements. It takes six weeks to eighteen months for this worm to develop.

Trichinella spiralis. The adult form of this worm lives in the upper part of the small intestines and is 1 to 4 m. m. long. After the male fertilizes the female, the latter burrows into the lining of the intestine and for a period of about six weeks emits larval stage worms into the lymphatic and venous vessels of the host. The worm does not expel eggs from its body. It is viviparous, that is, the eggs develop into larvae within the female worm, and it extrudes them only as larvae. Each female worm produces 1, 000 to 10, 000 larvae. The usual hosts of this parasite are the hog and the rat, but man also becomes parasitized. After the tiny larvae are expelled from the adult worm they are carried to various parts of the body, especially to the active muscles. The diaphragm muscles are commonly parasitized, but any muscle or any organ may be affected. If the worms find a haven in the brain or other vital part, serious complications may ensue and even death. After the larvae reach the muscle or other tissue they become encysted and may remain encapsulated and viable for 10 to 20 years. In the encysted state, they are 1/4 to 1/2 m. m. long. When people eat uncooked or uncured pork, the encysted forms are liberated in the intestines and develop into adults in a few days. Rats become infected by eating offal of hogs or by consuming other rats which are infected. The feeding of uncooked garbage containing scraps of infected

meat is the most common way of perpetuating the infection among hogs. It has been estimated that 5 to 20 percent of the people in the United States are infected with these worms. The control of trichinosis diseases hinges on the problem of garbage feeding to hogs, rat control, and teaching people the necessity of adequately cooking hog meats.

Wuchereria bancrofti is a thread-like, white, translucent worm whose definitive host is man and whose intermediate host is the mosquito. Filariasis is a tropical disease but was found around Charleston, South Carolina a generation ago. It is carried by many types of Culex, Aedes, and Anopheles mosquitoes, but the most important vector is Culex quinquefasciatus (C. fatigans.) The adult worm is 40 to 90 m. m. long. It prefers to live in the small lymph and blood vessels of the tissues. By so doing, these worms interfere with the circulation of tissue fluids, causing various parts of the body, which harbor them, to swell up, sometimes to enormous proportions. The most usually affected parts of the body are legs and scrotum. The affected parts become so large that the disease is called elephantiasis. The female worms produce young larvae in a similar manner as does Trichinella spiralis: that is, the eggs develop within the body of the worm, being expelled in the larval stage from the female. The young larvae live in the blood and lymph channels of the body. A peculiar phenomena about this disease is that during the day when mosquitoes do not usually bite, these larvae disappear from the peripheral blood vessels, but at night time when mosquitoes are most apt to bite, they are easily found in the peripheral circulation. It is not uncommon to find as many as 300 to 500 larvae in a single drop of blood during the night time. When the mosquitoes take their blood meals, these parasites get into their bodies where they go through a stage of development. Then when the mosquito bites other persons, it injects these infective larvae into their bodies. Thus the cycle of spread of the disease is: infected person to mosquito to uninfected person. This is similar to the malaria cycle. The control of this disease is bound up with the mosquito control program.

The life histories of the flat worm parasites are as follows:

1) Taenia saginata, the beef tapeworm, has man as the definitive host and cattle as the intermediate. Next to the dwarf tapeworm, it is the commonest tapeworm found in man in the United States. The adult form is 13 to 26 feet long, it lives in the upper part of the small intestines and is composed of several hundred to two thousand segments. The adult may live for at least several years in the human intestine to which it attaches itself by its head or scolex. Its body is composed of segments which, when mature, are full of eggs. The segments develop just below the scolex; those closer to the head are the young segments and those at the distal end are the older mature segments. After the mature segments break off from the worm, their covering disintegrates and liberates the eggs. Thus, if the segment does not disintegrate before it is passed by the feces, the eggs may not be found spread throughout the fecal material; but if the segment disintegrates within the intestinal tract, then the eggs can be detected microscopically, scattered throughout the feces. If sanitary facilities are poor or absent, the feces and the eggs become scattered over the ground and in the pastures where the eggs may live for eight weeks or longer. As the cows go about grazing, they swallow the eggs which are spread over the vegetation. When the egg reach the cow's stomach, the egg-cover splits and the embryo (onchosphere) is liberated in the small intestine. It bores its way through the intestinal wall and may be carried to various organs such as the diaphram, heart, tongue, etc. by the blood stream or by its own migratory efforts. Finally, it becomes encysted in some organ. This form is called the cysticercus or larva. It may remain in the beef muscle for many months. The cysts are 6 to 8 m. m. in size and can be seen by the naked eye.

When the cow is slaughtered and the meat consumed without being well cooked, the cyst walls disintegrate and the larvae are liberated in the human intestine where they grow to maturity. These worms cause diarrhea, hunger pains, ravenous appetities, loss of weight, debility and if allowed to go on for a long time do much damage to the well-being of people.

Here the sanitarian has an excreta control problem, a meat control problem, and an educational problem.

2) Taenia solium, the pork tapeworm, is rare in the United States, but does occur. Its life cycle and human damage is similar to that of the beef tapeworm except that this worm has the pig as intermediate host.

3) Hymenolepis nana, the dwarf tapeworm, is the smallest human tapeworm. The adult is 10 to 40 m. m. long and may have 100 to 2, 000 very small segments. The adult is so small that it looks like a delicate strand of mucus in the feces. It does not require an intermediate host and therefore it is very easy for those who do not practice good personal hygiene to continue to become superinfected by swallowing the eggs present on their dirty fingers.

This tapeworm is the commonest among man in this country, but it is also very common among rats. Tape worm eggs are not infective until the embryo becomes developed within the egg. These embryonated eggs reach the human mouth either by dirty hands which have touched human feces, or by foods which are contaminated by rat droppings. When they reach the intestines the embryo (onchosphere) is liberated from the egg and it penetrates into the superficial layers of the intestinal lumen as a larva, and attaches itself to the wall of the intestine. Here it developes into a mature adult. From the egg stage it takes 15 to 20 days to develop to a mature adult; therefore, about a month after the eggs are swallowed one would expect to find eggs in the feces of the infected person.

Here the sanitarian has, besides other sanitary measures, a rat and food control problem.

4) Hymenolepsis diminuta. This tapeworm is common in rats and mice and is found frequently in man. It is 20 to 60 c. m. long, and has about 1, 000 segments. Its eggs resemble those of Hymenolepis nana. This worm does have intermediate hosts. They are various species of insects and myriapods (thousand leggers) including meal and grain insects and rat fleas. Infection occurs by swallowing an infected intermediate host. The infected insects have been found in dried fruits, breakfast cereals, etc. Such insects become infected by feeding on mouse droppings.

Here the sanitarian has a rat, mouse, and food control problem.

5) Dipylidium caninum, or dog tapeworm may also be found in cats and human beings, mainly among children. They are 15 to 30 c. m. long and their eggs resemble that of Hymenolepis nana. The intermediate hosts of this parasite are the larval stages of the dog and cat fleas, also lice. These intermediates become infected from the feces which dogs and cats deposit on the ground. Children may become infected during play with dogs and cats by crushing the insects on their hands and then conveying the eggs on their fingers to their mouths.

6) Echinococcus granulosus produces what is known as Hydatid disease. This parasite has dogs, cats, and other carnivorous animals as its definitive hosts. Its intermediate hosts are cattle, sheep, hogs, and at times man. This disease is not often found in man in this country, but it does occur enough to make public health workers conscious of its existence. The eggs of this parasite resemble those of the beef tapeworm. The eggs are passed in the feces of the cat, dog, or other definitive hosts. Man becomes parasitized by swallowing these embryonated eggs through insanitary practices. The embryo breaks through the egg shell in the intestines and penetrates the intestional wall within eight hours. It gets into the blood stream and reaches the liver or other organs where the larvae encyst. These cysts grow larger and larger and produce symptoms and disease by pressure in vital areas. It is a dangerous disease and the fatality from it is high.

7) Diphyllobothrium latum or fish tapeworm, is found around the great lakes in the United States especially in northern Minnesota, Michigan and proximal Canadian territory. The adult may become over 30 feet long. It has 3, 000 to 4, 000 segments. The eggs reach water by dumping feces from infected persons into streams or other bodies of water. When feces is evacuated on the ground, the eggs may be washed into streams. Cats, dogs, and other animals, besides man, may be the definitive hosts of this parasite. After about three weeks in the water the lid of the egg opens and a ciliated (hairy) embryo escapes, which is microscopic in size. It may live several days in the water until it is swallowed by minute water animals called cyclops. This is the first intermediate host. After developing for about 15 days in the cyclops, it becomes a larva. When the cyclops are swallowed by fish such as pike, pickerel, perch, trout, salmon, etc., the larva penetrates through the stomach wall of the fish and passes into its muscle tissure. This is the second intermediate host. Here the parasite develops into a later larval stage resembling a worm and attaining 8 to 16 m. m. in length. When raw fish, or poorly cooked fish, is eaten by man or other host, the larvae are liberated into the small intestine where they rapidly develop into the adult stage. In about 18 days, they may reach the length of 2 feet and begin to discharge

eggs. They may live in man for many years.

This tapeworm causes an anemia in humans which resembles pernicious anemia, besides the other abdominal and debilitating symptoms which tapeworms in general cause.

The sanitarian in this case has an educational problem both among the public and among food handlers. The excreta control problem is here present as in the rest of the intestinal parasite control programs. Children should be kept out of kitchens and markets where fish is handled. Raw fish should not be fed to cats and dogs in the area where this tapeworm is a hazard.

Summary: - It is clear from the description of the life cycles of the worm parasites which infest man, that the control of the diseases which they produce is primarily a sanitary problem, and that the techniques of control are predominantly in the province of the sanitarian's work. The techniques mostly concerned with control of these worms are associated with: 1) Excreta control, 2) Meat and food control, 3) Rat control, 4) Mosquito control, 5) Garbage control, 6) Personal Hygiene.

Because of the nature of our understanding of the diseases produced by these worms, and because of the nature of the life cycles of these parasites, we can categorically say, that if we supply adequately the facilities demanded for control of these diseases, we can unquestionably eliminate these diseases from mankind. Thus the status of control of these diseases may be summarized as follows: 1) We know the causes, 2) We know the life cycle of the parasites, 3) We know where to break the chain in the life cycle, 4) Our knowledge of control methods to break the chains is adequate. 5) Therefore, we can eliminate these diseases with adequate facilities.

The only practical quick method of controlling hookworm is:

1) Furnishing sanitary excreta disposal to every family.
2) Working out a program of adequate nutrition for the entire population in affected areas.
3) Treating all affected cases, especially at the beginning of the winter season.
4) Reorganizing the economy of the southern farmer to prevent the endless migrations of the poorest and therefore the most infested families.

Hookworm is as much an economic as a sanitary problem. Hookworm, like many other diseases, will be quickly controlled by raising the standards of living of the farmer.

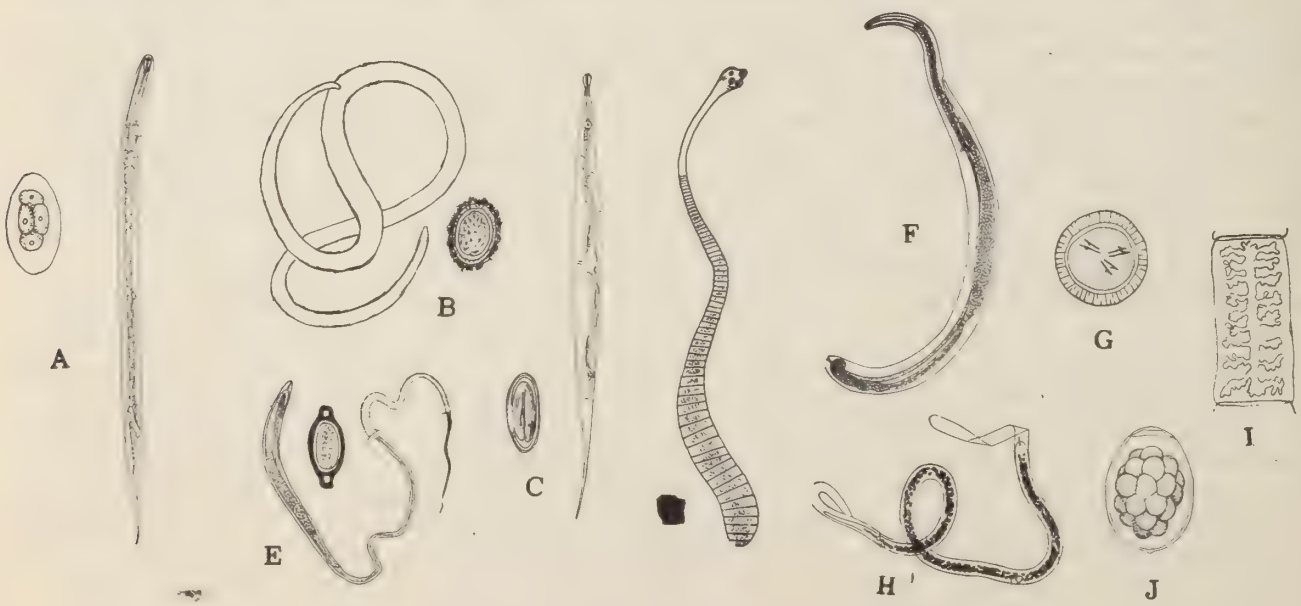


Fig. 1. WORM PARASITES

LEGEND

A -- Egg and larva of Necator americanus (Hookworm); larva is 160 times natural size.

B -- Egg and female adult of Ascaris lumbricoides (Large Round Worm); adult is natural size.

C -- Egg and female adult of Enterobius vermicularis (Pin worm or Seat-worm); adult is 16 times natural size.

D -- Adult Tapeworm, Hymenolepis nana; 15 times natural size.

E -- Egg and female adult of Trichuris trichiura (Whipworm); adult is 6 times natural size.

F -- Female adult Trichinella spiralis; adult is 90 times natural size.

G -- Egg of Taenia Saginata (Beef tapeworm); 666 times natural size.

H -- Adult Wuchereria bancrofti found in blood; 666 times natural size.

I -- Gravid segment of Taenia solium (Hog tapeworm); 500 times natural size.

J -- Egg of Diphyllobothrium latum (Fish tapeworm); 500 times natural size.

It must be remembered that the eggs in the above illustration are actually microscopic in size, whereas the worms are actually from several millimeters to many feet long. All the parasites illustrated are intestinal inhabitants except the microfilaria Wuchereria bancrofti, which is a blood and lymph stream inhabitant. There are no egg stages shown for Trichinella spiralis and Wuchereria bancrofti since these worms are viviparous (the females carry their young beyond the egg stage.)

Chapter VII

INSECT CONTROL

Insect control has become a basic function of the sanitarian since Manson in 1878 discovered that filaria was transmitted by the mosquito, Ross in 1897 discovered that malaria was transmitted by the mosquito, Smith in 1898 discovered that Texas cattle fever was transmitted by the tick, and Reed in 1901 proved that yellow fever was spread by the mosquito. Until recent years this was a difficult task since few effective single measures were known for the practical application in the control of insects. With the discovery of DDT and other synthetic insecticides, control measures have become practical for most disease carrying insects. The Food, Drug and Cosmetic Act further extended the sanitarians' function in insect control, for it designates as unfit for human food that which consists "wholly or in part of any filthy, decomposed, or deleterious substance." This has been interpreted to mean that live or dead insects, their eggs, larvae, pupae, cast skins, and droppings, rat and mouse droppings and urine, and bird droppings are all adulterants and contaminants of food. Sanitarians must therefore be well versed in the control of disease carrying insects and certainly have some fundamental information in the control of such insects as adulterate and contaminate food.

Before World War I, public health workers relied on arsenicals, sulfur, petroleum oils, and pyrethrum to control insect-borne diseases. During that War, hydrocyanic gas and mercury preparations were used for vermin control. During the next two decades, the fluorine compounds were added to the inorganic and rotenone to the botanical insecticides, paris green came into world-wide use as a mosquito larvicide, and the dinitro and thiocyanate compounds were tested as synthetic organic pesticides. During World War II, the chlorinated hydrocarbons, particularly DDT and BHC came into use, and with these, a new era in synthetic chemical pesticides began which is changing the entire armamentarium used in insect control. Tens of thousands of synthetic chemicals, particularly organic, have been evaluated for insect, rodent, weed, and fungus control. Hundreds of these are now in daily use in pest control, and additional materials are being developed continually. The more common pesticides used for public health purposes are discussed here.

Insecticides may be classified in various ways. If classified according to mode of entry into body, four classes would be identified: (1) Stomach poisons: These must be swallowed by the insect to cause death; (2) contact poisons: These must penetrate the body wall of the insect to produce death; (3) fumigants: These are vapors which enter the insect body through breathing pores and body surface; (4) dessicants: These are dusts that scratch, abrade, or absorb the fatty, water-resistant outer layer of the insect exoskeleton causing death by dehydration.

Classification may be based on the insect stage of development upon which the insecticide acts. (1) Ovicides kill the egg stage. (2) Larvicides kill the immature states. (3) Adulticides or Imagocides kill the adult state.

Classification may also be based on type of organisms which are killed, or the type of chemical to which the insecticide belongs.

Clinical Symptoms of Poisoning

For chlorinated hydrocarbon poisoning, the early symptoms are: nausea, vomiting, malaise, dizziness, tremors. The later symptoms are: generalized convulsions, respiratory depression which may be followed by death.

For poisoning by the organophosphorus compounds, the symptoms are: sweating, salivation, increased bronchial secretions, vomiting, colic, diarrhea, blurred vision, bradycardia, muscle tremors, cramps. The later symptoms are: bronchospasm, pulmonary edema, cyanosis, convulsions, coma, and death may follow. The symptom complex of increased secretions, asthmatic breathing, muscle tremor and convulsions is most suggestive of this type of poisoning. PAM shows promise in treatment of organophosphorus poisoning.

Precautions in the Use of Pesticides

1. Avoid inhalation of powders, dusts, sprays, or mists.

2. Protect skin from contact with poisons.

   a. Use neoprine-dipped or rubber gloves

   b. Use goggles when necessary (spraying organic phosphates)

   c. Change clothes when necessary

   d. Wash skin immediately when contaminated

3. Label all pesticides carefully, keep away from food, children, and irresponsibles.

4. Do not spray into wind.

5. Avoid fire hazard occasioned by smoking, defective wires, open flames. Read labels and know poisonous content of all insecticides and rodenticides in household and the antidote.

There are more than 50 commonly used pesticides and 5 antidote methods.

First Aid for Internal Poisoning

1. Call physician.

2. If unable to reach physician, call fire department rescue squad.

3. For special information, call nearest poison control center.

4. Determine nature of poison, select suitable antidote from Table below.

5. Apply the antidote.

Antidote 1: Induce vomiting by finger down throat (if this fails, give 1 tablespoon salt in glass of warm water, and repeat until vomit is clear); then 2 tablespoons epsom salts or milk of magnesia in water; then plenty of milk and water; keep warm, quiet.

Antidote 2: Induce vomiting by finger down throat (if this fails, give tablespoon salt in glass of warm water and repeat until vomit is clear); give plenty of milk and water.

Antidote 3: Take no action until physician arrives as immediate danger is not great.

Antidote 4: Give copper sulfate (1/2 teaspoon in glass of water) followed by bicarbonate of soda (1/2 teaspoon in glass of water); then 1 tablespoon salt in glass of warm water (repeat until vomit is clear); then 2 tablespoons epsom salts in glass of water; large amounts of water; NO MILK.

Antidote 5: Within 10 minutes of poisoning give 1 tablespoon salt in glass of warm water to induce vomiting (after 10 minutes do not give salt), next give 1 teaspoon activated charcoal in 1/2 glass water; have victim lie down in quiet, dark room; keep body warm.

Table 1

ANTIDOTES FOR PESTICIDE POISONING

Pesticide	Antidote	Pesticide	Antidote
Aldrin	1	Methoxychlor	1
ANTU	1	Nicotine sulfate	1*#
Arsenic trioxide	1	Para-dichlorobenzene	1
Barium Carbonate	1	Parathion	2*
BHC	1	Paris green	1
Chlordane	1	Pentachlorophenol	1*
Cyanide	2*	Phosphorus	4
DDT	1	Pival	3
DDVP	2	PMP	3
Diazinon	2	Pyrethrum	2
Dieldrin	1	Red Squill	2
Dilan	1	Rotenone	2*
Diphacin	2	Silica gel	3
Endrin	1	Sodium fluoride	1
Fumarin	3	Strychnine	5
Heptachlor	1	Ten-eighty (1080)	1/
Korlan	2	TEPP	2
Lead Arsenate	1	Thallium sulfate	2
Lindane	1	Warfarin	3
Malathion	2	Zinc Phosphide	4

*Also artificial respiration as required; no liquids if unconscious.
#Also strong tea or coffee; cold head packs; keep body warm.
/Also vinegar (1 teaspoon in glass of water).

Chlorinated Hydrocarbon Insecticides

DDT Series

DDT (C_{14} H_9 Cl_5 - dichloro-diphenyl-trichloroethane), was the first of the important chlorinated hydrocarbons that came into use as an insecticide. It is the choice insecticide for mosquito larvae and adults, bed bugs, fleas, lice, non-immune flies, and many other insects. It is a fine white powder and tends to become lumpy when not mixed with other substances. It

dissolves very little in water or alcohol, but is soluble in many organic solvents. A 5% DDT solution in kerosene, plus an auxiliary solvent, has been used for residual treatment of buildings to control mosquitoes, flies, ticks and other arthropods. Compounds with structural formulae similar to DDT include DDD (DTE), methoxychlor, perthane, DMC, and Dilan. These have been used in controlling flies, mosquitoes, and other arthropods. DMC, di (p-chlorophenyl) methylcarbinol and Dimite, a 25% emulsifiable concentrate of DMC and perthane have synergistic action in combination with organic insecticides such as DDT or malathion and are used in controlling resistant flies and mosquitoes. DDD or DTE, ($C_{14}H_{10}Cl_4$), an analogue of DDT, has been found equally as toxic as DDT as a mosquito larvicide and of lower toxicity to fish and shellfish when used in the effective dosage of 0.05 lb. per acre. It is less effective than DDT for most arthropods. It is sold commercially as Rhothane D-3. Another analogue, methoxychlor, ($C_{16}H_{15}O_2Cl_3$), is less toxic than DDT. It has a fast knock-down for flies and a satisfactory residual effect, but it cannot be unqualifiedly endorsed against flies due to its variability of action. It is approved for use in dairy barns, food handling establishments, and for ectoparasites, or where insects have resistance to DDT. Chlorobenzilate ($C_{16}H_{14}O_3Cl_2$) and Kelthane have shown considerable promise in controlling mites.

The detailed description of the use of DDT in mosquito control will be found in the chapter on Malaria and Mosquito Control.

Dilan is a mixture of 2-Nitro-1, 1-bis (p-chlorophenyl) propane (1 part), known as Prolan, plus 2-Nitro-1, 1-bis (p-chlorophenyl) butane, (2 parts), known as Bulan. Technical dilan is a tan to brown plastic semi-solid with a pleasant fruity aromatic odor. It is practically insoluble in water but soluble in many common organic solvents. An emulsion of 2.5% for space spraying is effective against DDT resistant flies, but flies become resistant to it also. Residual spraying with 2.5% suspension at rate of 125 mg. to 200 mg. per square foot has controlled house flies for 6 to 13 weeks. Dilan and DDT may be mixed for effective fly control. Dilan can be used as residual spray in concentrations up to 10%. Dilan is effective against agricultural pests, particularly Mexican bean beetles and potato leafhoppers. Emulsifiable concentrates are readily made from the technical form or liquid concentrates in same manner as DDT is prepared. It is somewhat less hazardous to mammals than DDT, however, the same precautions should be used in handling it.

Chlordan Series

Chlordan or 1068, ($C_{10}H_6Cl_8$), is a dark, viscous, oily liquid, soluble in most organic solvents but insoluble in water. It is commercially available as wettable powders, emulsifiable or solubilized concentrates, oil solutions, low percentage dusts and technical chlordan. Upon standing for long periods of time, it tends to solidify to a somewhat gummy mass, which is nevertheless readily soluble in organic solvents. It readily decomposes with liberation of hydrochloric acid and may attack metal containers. It should therefore be stored in glass, aluminum, aluminum-clad steel, or high-bake phenolic lacquer lined metal containers. Therefore, sprayers must be washed thoroughly at the end of each day's work.

It is more toxic to man and animals that DDT, therefore breathing its fumes, dusts, powders, mists, or contact with skin should be avoided. Contaminated skin areas should be washed immediately with soap and water. It is particularly useful against DDT-resistant flies, also for roaches, ants, termites, and a wide range of insects. The recommended concentration for usual usage as a residual spray is 2% to 3%. Dusts are commonly used in 5% concentration.

Heptachlor ($C_{10}H_5Cl_7$), also known as E-3314, Velsicol 104, and Velsicol Heptachlor, is an analogue of chlordan and is a white crystalline powder in pure form, readily soluble in many organic solvents and has a mild camphor-like odor. It is more volatile than DDT and therefore has less residual effectiveness. It is 4 to 5 times as toxic to many insects than chlordan, but is also more toxic to humans and animals. Technical heptachlor is soft, waxy, and light tan in color. Although it is an effective insecticide against cotton insects, wireworms, corn root worms, grasshoppers, alfalfa weevils, western harvester ants and other agricultural insects, it is also effective against flies, roaches, larval states of sand flies (Culicoides spp.),

mosquitoes, larval stages of eye gnats (Hippelates spp.) and other household pests. The recommended dosage against larval form of eye gnats is 2 lb. per acre, sand fly larvae 1 lb. per acre, and mosquito larvae about 0.1 lb. per acre. Same precautions should be used as for chlordan. As a residual spray it is used in 0.5% to 1.0% concentrations.

Aldrin ($C_{12}H_8Cl_6$), also known as Compound 118 or Octalene, is a compound closely related to chlordan. It is a white crystalline solid which is soluble in most organic solvents and is insoluble in water. Unlike most other chlorinated hydrocarbon insecticides, it is stable in the presence of alkaline and metallic chloride materials. It is more volatile than chlordan and possesses considerable fumigant properties. It is effective against many agricultural insects, particularly grasshoppers and cotton pests. It is also effective as a larvicide against flies, mosquitoes, sand flies (Culicoides spp.) and eye gnats (Hippelates spp.) and as a residual spray against flies, mosquitoes, fleas, roaches and other household pests. However, because of its volatility, it does not have as long-lasting residual effect as DDT or dieldrin. It is much more toxic to man and animals (including fish and other aquatic organisms) than DDT and should be used with extreme caution, avoiding inhalations of vapors, dusts, or mists and direct skin contact. As a residual spray, it is used in 0.5% concentrations.

Dieldrin ($C_{12}H_8Cl_6O$), known also as Compound 497 or Octalox, is closely related to aldrin and the same precautions against its toxicity must be taken as against aldrin. It is a white crystalline solid moderately soluble in organic solvents but insoluble in water. The technical grade material may have a slight tinge of brown or rust color. It is slightly volatile but stable in the presence of alkalies and weak acids and has prolonged residual effectiveness, greater than DDT. It is extensively used for a variety of agricultural insects and forest pests. It is effective as a residual spray against flies, mosquitoes, ants, roaches, earwigs, triatoma bugs (Chagas disease), clothes moths, tapestry moths, carpet beetles, and other household pests; as space sprays against adult flies and mosquitoes; as larvicides for control of fly, mosquito and sandfly larvae; and as sprays and dusts against ticks. Its use should be limited to places where contamination of food and food products of man and animals is not a problem and where the risks to operators applying it can be kept low. House flies build up a high degree of resistance to dieldrin. As in the case of aldrin, it is readily formulated as wettable powders, emulsifiable concentrates, oil solutions, impregnated pellets, and low percentage dusts. Where flies have become resistant to DDT it may be used outdoors. For chigger control use 1 lb. per acre as a dust or spray. As a residual spray, it is used in concentrations of 0.625% to 1.25%.

Toxaphene ($C_{10}H_{10}Cl_8$), also known as Compound 3956, is a chlorinated camphene, and is an amber, waxy solid having a mild odor suggestive of chlorine or camphor. It is readily soluble in oils and most organic solvents but insoluble in water. Although it is effective against adult flies, mosquitoes, ants, ticks, other household and agricultural pests, and fly and mosquito larvae, its greater toxicity and less effectiveness than DDT minimizes its usefulness in public health. The recommended use for it at present is for control of agricultural pests and against DDT resistant mosquito larvae in irrigated agricultural areas applied at the rate of 0.25 to 0.50 lb. of toxaphene per acre. It is used alone or in combination with lindane or malathion as a live stock spray, dip, or dust to control horn flies, lice, ticks, and scabies mites.

Isodrin and Endrin are two very toxic insecticides. Not used much for public health purposes, but for agricultural pests. Residual sprays of endrin have been applied to vegetation in orchards to kill meadow mice and field rodents.

Kepone is a chlorinated polycyclic ketone and acts as a stomach poison. It is used for control of German and brown-banded roaches. Peanut butter pellets containing 0.125% kepone is used as a bait for roaches and fire ants. The pellets should be small enough for insects to carry.

Benzene Hexachloride Series

Benzene Hexachloride ($C_6H_6Cl_6$-hexachlorocyclohexane) also called BHC is a dirty crystalline solid, not soluble in water, but soluble in varying degrees in a wide variety of

common solvents. There are 16 possible geometrical isomers of this compound, five of which occur in technical benzene hexachloride. Of the latter, the gamma isomer is the most active insecticide and is called lindane. The name gammexane is applied by the British to either benzene hexachloride or lindane. Technical grades of BHC are available with 12% to 36% gamma isomer. BHC is available commercially as wettable powders, dusts, solutions, emulsifiable concentrates. It is toxic to man and should be used with somewhat greater precautions than DDT. It should not be applied to dairy animals nor to the food of man or animals. As a 3% dust, it is quite effective as a mosquito larvicide, and adulticide. It has a residual life of 2 to 6 weeks. The 12% gamma isomer has been applied to land locked ponds at the rate of 1 pound per acre and as often as five times per season with no detectable injury to fish and with satisfactory mosquito control for as long as 1 month per application. BHC wettable powder has been used as a fly larvicide, and for control of chiggers and ants. BHC (with DDT and dieldrin) are in general use as a residual spray for world-wide malaria eradication.

Lindane ($C_6H_6Cl_6$) is pure gamma isomer of benzene hexachloride. It is a white crystalline solid, insoluble in water but soluble in most organic solvents though not as soluble as DDT. It has a musty odor, is more volatile than DDT and has considerable fumigating properties. It is more toxic to insects than DDT, therefore its formulations are about one-tenth as strong as DDT. It is effective as a residual spray against flies, mosquitoes, roaches, and other household pests; as a space spray against adult flies and mosquitoes; as a larvicide against fly and mosquito larvae; and as dust and spray against ticks, mites, fleas, and a variety of agricultural pests. Because of its volatility, its effectiveness as a residual spray is limited. But when used the spray concentration should not exceed 0.5% to 1.0%. It is the most toxic of the benzene hexachloride isomers, but is excreted relatively rapidly and therefore shows the lowest chronic toxicity. Because of its acute toxicity, care should be taken to avoid breathing fumes, dusts, sprays, or contact with skin. It should be washed off skin promptly with soap and water. Canaries and tropical fish, being very susceptible to this poison, should not be exposed to its vapor. 1% or 2% formulations will readily control hornets, wasps, and yellow jackets.

Lindane vapor produced by electric vaporizers can penetrate packaged foodstuffs such as breakfast cereal. Under certain circumstances the vapors can condense on solid surfaces and then revolatilize.

Organic Phosphorus Insecticides

These insecticides are inhibitors of cholinesterase enzyme.

Bayer 29493 ($C_{10}H_{15}O_3PS_2$), also called Entex. It is moderately toxic. It shows promise in mosquito, fly and cockroach control, usually as 2% to 3% sprays. It is registered as 5% granules, as wettable powder, and as emulsion concentrate.

DDVP ($C_4H_7O_4PCl_2$) is highly volatile and has a short residual life. Its vapors are toxic which adds quick "knock-down" to many dry and liquid fly baits. Its vapors will penetrate hard-to-reach infestations of cockroaches and brown dog ticks. It is effective as a 0.5% spray for many household insects including flies, cockroaches, fleas, brown dog ticks, cigarette beetles and tobacco moths. It is very good as a residual fumigant in malaria eradication.

Diazinon ($C_{12}H_{21}O_3N_2PS$). This is a moderately toxic insecticide. Sprays of 1% are used for fly control in food plants. Residual bait sprays containing 2.5% diazinon and 6.25% sugar are effective for fly control for a month or more. For dairy barns, loading platforms, and the like, flies can be controlled with fly cords impregnated with diazinon or a mixture with parathion. It is quite effective for german cockroaches that are resistant to chlorinated hydrocarbons or malathion when used as 1% spray for first application and 0.5% spray or 5% dust for routine follow-up. It has a relatively short residual life.

Dibrom ($C_4H_7O_4Br_2Cl_2$) is closely related to DDVP. It is a contact and stomach poison and has a limited amount of vapor toxicity. Technical grade dibrom is liquid at room temperature. It is purchased as a 64.5% emulsifiable concentrate containing 8 pounds of dibrom per gallon or as a 4% dust. In aerial treatment against salt marsh mosquitoes (adult), oil solutions at application rates of 0.05 to 0.1 pounds of dibrom per acre produces excellent kills. It is used also as liquid bait for flies in dairy barns or as space spray for fly control.

Dimethoate ($C_5H_{12}NO_3PS_2$) is used for outdoor fly control in dairy farms and gives 6 to 10 weeks residual effectiveness. It gives good results for flies resistant to other insecticides. It has an objectionalbe odor and stains when used indoors.

Dipterex ($C_4H_8O_4PCl_3$) is water soluble and therefore can be used where odor of insecticides or solvents are a problem such as in hospitals or eating establishments. It is a rapidly acting stomach poison and is used in fly control as a 1% dry sugar bait or 0.1% liquid bait in dairy barns, poultry houses, stables, kennels, picnic areas, and garbage areas. It is also effective against cockroaches by spot application of 1% to 2% solutions or emulsions or as dry sugar bait.

Malathion ($C_{10}H_{19}O_6PS_2$) is one of the safest insecticides, being less toxic than DDT, and is used against a wide range of mite and insect pests, including flies, cockroaches, and mosquitoes resistant to DDT and other insecticides. It may have a disagreeable odor. Up to 5% sprays are used for spot treatment against cockroaches, particularly the german roach. Up to 4% sprays are used for crawling arthropods and fleas. 5% malathion with 12.5% sugar is used for residual spray for fly control. Mist and fog formulations with 6.5% fuel oil solutions of malathion are used for DDT-resistant flies and mosquitoes. Suspensions of malathion (5%) are used for control of anopheles resistant to dieldrin and DDT. Dusts (3% to 5%) or sprays (0.5%) are used for DDT resistant cat and dog fleas (for one to two weeks in summer and a month in winter). Sprays of 1% are used for DDT-resistant bed bugs, clover and bird mites. A 1% dust is used for human lice resistant to DDT or lindane.

Parathion ($C_{10}H_{14}NO_5PS$) is related to the highly toxic chemicals (TEPP-tetraethyl pyrophosphate, and HETP-hexaethyl tetraphosphate). These are dangerously toxic to animals through inhalation, skin absorption, and swallowing. It is used for agricultural insects. In public health, it is used as fly cords and in mosquito control. Impregnated cords are used for fly control in barns and similar places. It may be used at the rates of 0.05 to 0.1 pound of technical material per acre for DDT resistant mosquitoes. (C. tarsalus, Aedes nigromaculis, A. sollicitans, A. taeniorhynchus) as emulsions, solutions, or granular. The related insecticides, such as Guthion (methyl parathion), are not as toxic as parathion but have much more limited use.

Ronnel ($C_8H_8O_3Cl_3PS$) is also known as Korlan, Dow ET-14, Dow ET-57, or Trolene. It has low mammalian toxicity, and is used for fly control in dairy barns and food processing plants, for cockroach, mite, spider, tick, lice, flea, and bed bug control as 1% to 2% spray. It has less objectionable odor than malathion, particularly if applied in oil. It does not stain whitewash surfaces. It is used as a spray for ectoparasites in cattle and dogs.

EPN ($C_{14}H_{14}O_4NPS$), known also as EPN 300 insecticide, is a dark amber viscous liquid with a garlic odor in the technical form. It is slightly soluble in water and readily soluble in most organic solvents. The pure compound is crystalline with a melting point of 36°C. Although it is principally used in agriculture as an acaricide on deciduous and citrous fruit trees, it has been found highly successful as a larvicide against mosquitoes, particularly Culex tarsalis which have developed resistance to chlorinated hydrocarbon insecticides. It may be purchased commercially as wettable powders and as 1, 2, and 3% dusts. Protective clothing, including goggles and respirators should be worn at all times in handling it. It should not come into contact with the skin. Working clothes should be changed completely every day including underclothes. Operators must bathe every day immediately after work hours. It is applied at the rate of 0.035 lb. per acre and should be used only by trained personnel.

Phosdrin and TEPP are very highly toxic and hazardous to use.

Insecticides of Plant Origin

Insecticides of plant origin are among the safest of all insecticides. Among these are pyrethrum, rotenone, derris, hellebore, nicotine, quassie, camphor, and turpentine.

Pyrethrins with synergists (activators) give residual action against house flies, horse flies, deer flies, and roaches. Aerosols of such combination, used at the rate of 3 grams per 100 cu. ft., are effective against flies, mosquitoes, fleas, ants, clothes moths, sand flies, and gnats. It is also useful for fly control in dairy barns. Allethrin ($C_{19}H_{26}O_3$), is also known as synthetic pyrethrin, allyl homolog of Cinerin I, and Pyresyn. It is a clear, amber, fairly viscid liquid and has a mild pleasant odor. It is readily miscible with kerosene, xylene, and many other organic solvents, but is insoluble in water. It is equal in effectiveness to natural pyrethrins against flies and less effective against mosquitoes. It is also effective against the human body louse, roaches, bed-bugs and other household pests and can be effectively used for food plant insect control. It has a longer residual action than natural pyrethrins particularly when combined with sulfoxide. The addition of synergists such as MGK-264 (m-octyl bicycloheptene dicarboximide), n-propyl isome, sulfoxide piperonyl butoxide, m-nitrobenzamides, and sesame oil generally increases its effectiveness against household insects. This is among the least toxic insecticides to mammal. DDT, chlordan, or toxic ingredients added to allethrin increases its toxic qualities. It can be bought commercially as oil solutions, emulsifiable concentrates, low percentage dusts and aerosol preparations.

Rotenone is a white, crystalline solid extracted from plant roots. It is a stomach and contact poison. Its action is to slow the heart beat and paralyze the respiratory system and is effective against many arthropods of public health and agricultural importance. It has a low toxicity for mammals. It is used to control fleas, lice, ticks, flies on domestic animals. It is applied to the back of cattle to control cattle grub (Hypodermia.)

Ryania is a plant extract, and also a stomach and contact poison. It has a low toxicity for warm blooded animals. It is used on vegetables for protection against insects, but shows no promise for public health purposes.

Sabadilla is obtained from seeds of the sabadilla plant. It has low toxicity for warm-blooded animals and is used against cattle lice, house flies, and other insects.

Nicotine is extracted from tobacco but has no forseeable public health use.

Fuel Oils and Kerosene

These are extensively and effectively used as insecticides and as solvents of insecticides.

Organic Thiocyanates

Many of the aerosols for household insects and cattle sprays, and the oil-base contact insecticides for general application in household, dairy, mill, and warehouse disinfection contain one or more of the organic thiocyanates. They are also used in airplane application and fog and mist machines for pest mosquito control - either in fuel oil, or in combination with fuel oil solutions containing DDT or malathion. They produce rapid knock-down of insects, have low toxicity for warm blooded animals, and rarely damage vegetation. They are heat stable and have unpleasant odors.

Loro (lauryl thiocyanate ($C_{12}H_{25}SCN$) has been used for louse control.

Lethane 384 ($C_4H_9OCH_2CH_2OCH_2CH_2SCN$) and Lethane 384 Special ($C_{11}H_{23}COOCH_2CH_2SCN$) are used in the control of household and dairy insects. They are added to petroleum house sprays as the sole toxic agent or in combination with DDT and other materials. They produce rapid knock-down of flies and mosquitoes.

Thanite ($C_{10}H_{17}OOCCH_2SCN$) is a knockdown agent for flies. It is used as a cattle spray and for general application in the home, dairy, and warehouse. It has a low toxicity for mammals.

Organic Nitrogen Group

This is a group of dinitro derivatives of phenol and cresol which are used as louse powders, moth-proofing agents, screw-worm dips, mosquito larvicides, apple orchard sprays. Not commonly used in public health.

Dinitrophenol is an insecticide and acaricide; DNOC, a powerful insecticide and ovicide; DNOCHP (dinitrocyclohexylphenol), an acaricide; DNOSBP, an insecticide; Diphenylamine, a screw-worm dip; Azobenzene, a mosquito larvicide and red spider insecticide; Karathane, an insecticide, acaricide, and mite ovicide; Prolan and Bulan, constituents of Dilan used for DDT resistant flies; Dinitronaphthol, a mothproofing agent; Dinitroanisole, a constituent of MYL louse powder used to kill lice eggs; Dinitrocresylate, an acaricide.

Organic Sulfur Group

These insecticides are esters of carbamic acid and are related to the fungicides such as thiram, ferbam, ziram, nabam, zineb, and certain new herbicides. This group can be used as insecticides for insects that are resistant to chlorinated hydrocarbons and organic phosphorus.

Sevin in a 0.5% spray is used for resistant brown dog ticks (indoors). 5% dust is used for general tick and flea control outdoors and for the face fly (Musca autumnalis) on dairy cattle.

Isolan has rapid action like pyrethrum for flies and bed bugs, and has short residual action.

Dimetilan is effective for fly control as impregnated fly bands.

Lauseto neu is effective for control of human lice, especially as an ovicide.

Phenothiazine is used as a mosquito larvicide and for agricultural insect control, also for control of the hornfly and maggots in fresh cow manure.

Aramite, Genitol, Ovex, and Sulfenone are primarily acaricides used to control agricultural pests; also clover mites and blood-sucking mites of birds or mammals such as infest pigeons or chickens.

Inorganic Insecticides

The inorganic insecticides are, to a large extent, the older substances in our armamentarium of poisons used before the recent revolution in chemistry. Sulfur dust is effective against chigger mites, other mites and red spiders. Sulfur dioxide fumigant has been satisfactorily replaced. Copper sulfate is still used as an agricultural fungicide and for controlling algae in lakes and ponds. Mercury chloride as a fungicide or ant poison, and mercurial ointments for human lice control are too hazardous considering the availability of more modern replacements. The arsenic group are still useful. Paris green (copper-acetoarsenite) vermiculite granules are excellent as a larvicide for anopheline and DDT-resistant culicine mosquito larval. Sodium arsenite solution is still used for ant baits. Lead arsenite dust or spray is effective against chewing insects, but is hazardous to humans. The fluorine group contains older and more modern chemicals. Cryolite (sodium aluminum fluoride) is a safe insecticide for controlling chewing pests in orchards and in vegetable crops. Sodium fluoride dust is effective against cockroaches resistant to modern chemicals, but it is toxic to humans. Sodium fluosilicate as wet-mesh bait is satisfactory for controlling many insects, and is quite effective for moth proofing of woolens. Sodium monofluoroacetate (1080) is an effective rodenticide but very poisonous to humans and animal pets. Borax

(sodium tetraborate) can be used for cockroach control, and is effective for fly control in manure and other feces, but should not be used in rates of more than 10 ounces to each bushel of manure which is intended for fertilizer. Borax is harmful to soil. Yellow phosphorus paste is effective for controlling the American and oriental cockroaches and rodents but is also hazardous to humans. Tartar emetic (potassusm antimonyl tartrate) is used as ant bait and agricultural spray, but is toxic for humans. Thalluim sulfate is a rodenticide but is toxic to humans.

Fumigants

Fumigants kill insects by penetrating the body and respiratory tract in gaseous form. Molecules of gas can penetrate cracks and crevices or penetrate tightly packed material. By contrast, aerosols, commonly called fogs or smokes, are discharged as very fine particles of liquid or solid which remain suspended in the air sufficiently long enough to distribute themselves throughout the area and act upon exposed insects. Aerosols do not penetrate materials. All modern fumigants which give effective pest control are also toxic to man. They are purchased in solid, liquid, or gaseous form.

Naphthalene ($C_{10}H_8$) is a solid and obtained from the distillation of coal tar. It is marketed as moth balls or flakes for controlling clothes moths and carpet beetles. It is a repellent of squirrels and rats. This fumigant has been largely replaced by PDB.

Paradichlorobenzine ($C_6H_4Cl_2$) also called PDB is a solid. It is one of the earliest chlorinated hydrocarbon insecticides. Besides being used to protect woolens and furs, it may be used to control fly breeding in garbage cans by the application of two ounces per can every one to two weeks.

Hydrogen Cyanide (hydrocyanic acid or HCN). This gas is widely used to control insects and rodents. (See also chapter on Rodent Control.)

Methyl Bromide (CH_3Br) is a heavy gas having great penetrating power for fumigation of vermin-infested clothing and stored products. It is mixed with chloropicrin in order to give it an odor for detectibility. It may be purchased in pound cans or large cylinders from which the gas is released through tubing into the area to be treated. It is non-flammable.

The following fumigants are used particularly for stored foods:

Acrylonitrile ($CH_2CH\ CN$) is inflammable and is used in mixtures of 1 part acrylonitrile and 2 parts carbon tetrachloride. It is useful as a local or "spot" fumigant, particularly for machinery in flour mills and bakeries.

Carbon Tetrachloride (CCl_4) is non-flammable and is used to dilute inflammable fumigants. It is very toxic both to insects and humans.

Carbon Disulphide (CS_2) is a pale yellow, inflammable, explosive liquid. It is used particularly for ant nests and for grain fumigation. Adequate follow-up ventilation must be done to prevent toxic symptoms in man.

Chloropicrin (CCl_3NO_2) is a highly toxic "tear gas." It is used in 2 to 5% proportions as a warning agent for other non-odorous fumigants and also as a soil fumigant. Not used alone as a general fumigant.

Ethylene Dibromide ($CH_2Br\text{-}CH_2Br$) is used as an ingredient in grain fumigant mixtures. It is also used in termite work as a soil fumigant or as a fumigant in grain mills.

Ethylene Oxide ($(CH_2)_2O$) is a widely used grain and food fumigant both to control insects and to prevent microbial spoilage, especially in dried fruit. It is highly inflammable and explosive. It is used as 1:9 carbon dioxide mixtures in aerosol bombs to sterilize instruments, bedding, and clothing placed in plastic bags or drum fumigators.

Phosphine (PH_3) is used as a grain fumigant. Special tablets are mixed with grain as it is stored. The tablets react with the moisture in the grain to produce toxic phosphine and ammonia carbonate gases which kill insects.

Sulfuryl Fluoride (SO_2F_2) can be used as substitute for methyl bromide. It is also used in drywood termite control.

Sulphur Dioxide (SO_2) kills bed bugs but is less effective than many other insecticides. It does not penetrate well, tarnishes metals, and bleaches some materials.

Dessicants or Sorptive Dusts

These are very finely powdered silica gels and aerogels that kill insects by removing the outer waterproof layer of the arthropod exoskeleton either by absorbing the fatty material or by abrasion. These are non-toxic to man or warm blooded animals and do not produce silicosis in man.

Repellents and Impregnants

Repellents are those substances which produce avoidance reactions in animals. Repellents that are used to impregnate clothing and which withstands laundering are called impregnants. Older repellents are oil of citronella, dimethyl phthalate (for mosquitoes, fleas, and black flies), indalone (for mosquitoes, ticks, and black flies), and Rutgers 612 (for mosquitoes, chiggers, and black flies). A combination of the latter three in the proportion of 6 parts, 2 parts, and 2 parts was a standard military all purpose repellent. More recently, the military standard all purpose repellents are: M-2020, composed 4 parts dimethyl pthalate, 3 parts Rutgers 612, and 3 parts dimethyl carbamate; and M-2043, composed of 4 parts dimethyl pthalate, 3 parts Rutgers 612, and 3 parts N, N-diethylsuccinamate. Diethyl toluamide (Deet) is also a satisfactory all purpose repellent. Effective impregnants are benzel benzoate, for fleas and chiggers, mixtures of benzyl benzoate and dibutyl pthalate chiggers, and benzil for chiggers. The present military standard impregnant is M-1960.

Attractants

These are materials used to lure insects into traps and to induce them to eat poisoned baits. Most attractants are of natural origin, some have been commercially synthesized.

Auxiliaries

An emulsifying agent is added to insecticidal emulsion concentrates in order that they may be mixed with water to produce relatively stable emulsions. Emulsifiers form a very thin coating on each individual droplet of the oil solvent containing the insecticide. This prevents the oil from separating from the water carrier. Earlier, soaps were used as emulsifiers. Modern emulsifiers are Tritons, Spans, and Tweens.

Some Definitions: Technical Grade insecticides are commercial grade materials used in preparing mixtures for subsequent use. Concentrated Stock Solutions are insecticidal materials dissolved in concentrated form in a solvent such as kerosene or diesel oil and an auxiliary solvent such as xylene. Emulsifiable concentrates are similar to stock solutions but have an added ingredient, an emulsifier, which causes the concentrate to become readily emulsified when added to water. Water-miscible or Wettable Powders contain an insecticide ground in an inert dust making them mix with water readily forming suspensions when a suitable wetting agent is added. These are non-inflammable, relatively odorless, and non-absorptive through the skin and are usually employed in spraying warehouses, stables and outbuildings. Insecticidal Dusts consist of toxic ingredients, such as DDT, ground in an inert carrier, such as talc or pyrophyllite and used for dusting. Finished Sprays are insecticidal solutions and emulsions in concentrations that are suitable for immediate use. Aerosol is liquid insecticide preparation used for producing a fine fog in space spraying to control flying insects. A typical formulation contains 0.4% pyrethrins and 3% DDT in sesame oil and cyclohexanone to make up 15% of oil concentrate, the

remaining 85% being Freon-12. The Freon liquid is confined within the container under pressure and volatilizes when a valve is opened, carrying with it a fine fog bearing the toxic ingredients. Synergists are compounds which, when added to an insecticidal material, activate the insecticidal properties; for example, when DMC (p-dichlorodiphenyl methyl carbinol) is added to DDT, the latter's insecticidal properties are enhanced against DDT resistant insects.

It must be kept in mind that any insect may possibly develop resistant strains to any of the organic insecticides that are being discovered.

Chart 1

Description of Formulations of Interest to Sanitarians

Formulation Name	The Usual Concentration of Toxicant in the Prepared Original Product (DDT, Chlordan, or BHC)	Appearance of Original Product	Dilution* for Spraying (Volume Parts)	Appearance of Diluted Spray Mixture
Oil Solutions	5%	Clear, colorless	None	Original Product
Emulsifiable Concentrates	25%	Clear, straw to amber color	1 part concentrate; 4 parts water for 5% spray	Milky white emulsion
Solubilized Concentrates	50% (Chlordan only)	Dark-brown, molasses-like	1 part concentrate; 12 parts water for 5% spray	Clear, slightly colored
Stock or Paste Emulsions	50%	White to cream colored mayonnaise-like	1 part concentrate; 9 parts water for for 5%	Milky white emulsion
Colloidal Suspensions	40% (DDT only)	White cream	1 part suspension; 7 parts water for 5%	Milky white suspension
Wettable Powders	50%	White powder	1/2 pound/gal. water	Milky white suspension

*Dilutions for spraying of living quarters at 200 milligrams per sq. foot.

Computations for Preparing Formulations

1. Dilution Formula for computing dilution rate:

$$X = \frac{C}{S} - 1$$

X = Number of parts of dilutent to add to 1 part of concentrate. C = Concentrate, percent of active ingredient. S = Strength or percent of active ingredient in finished spray or dust.

Example: Dilute a 25% lindane emulsifiable concentrate to 0.5% finished spray emulsion

$X = \frac{25}{0.5} - 1$, therefore, X = 50 - 1 or 49 parts, i.e., 1:49 dilution

2. Dilution Formula for preparing certain quantity:

$$Q = \frac{S \times A}{C}$$

Q = Quantity of concentrate required in mixture (pounds, gallons, ounces). S = Strength or percent of active ingredient in the finish dust or spray. A = Amount of finished spray or dust to be prepared (pounds, gallons, or ounces). C = Concentrate, percent of active ingredient.

Example 1: Prepare 100 pounds of 2% chlordan dust using talc and 5% chlordan dust.

$Q = \frac{2\% \times 100 \text{ lbs.}}{5\%}$, therefore, Q = 40 lbs. of 5% chlordan dust, therefore add 60 lbs. of talc.

Example 2: Prepare 50 gallons of 1% lindane spray using 25% emulsifiable concentrate and water.

$Q = \frac{1\% \times 50 \text{ gals.}}{25\%}$, therefore, Q = 2 gallons of lindane concentrate, then add 48 gallons of water.

Example 3: Prepare 1 gallon (128 oz.) of 0.5% diazinon emulsion from 20% diazinon emulsion concentrate and water.

$Q = \frac{0.5\% \times 128 \text{ oz.}}{20\%} = \frac{64 \text{ oz.}}{20} = 3.4$ oz of 20% diazinon concentrate, then add water to make up 1 gallon.

3. Dilution Formula for weight to weight preparation.

$$Q = \frac{S \times A \times D}{C}$$

Q = Pounds of concentrate to use. S = Strength or percentage of active ingredient in the finished spray. A = Amount in gallons of finished spray. D = Density: Weight of one gallon of diluent. C = Concentrate: Percentage of active ingredient.

Example 1: Make up 50 gallons of a 2.5 percent chlordan solution in deodorized kerosene. The kerosene weighs about 6.6 pounds per gallon. Use technical grade chlordan.

$$X = \frac{2.5\% \times 50 \text{ gallons} \times 6.6 \text{ lbs./gal.}}{100\%} = 8.25 \text{ lbs. of chlordan, and add kerosene}$$

to make up 50 gallons.

Example 2: Prepare 100 gallons of 2.5% DDT suspension from 50% water-wettable powder and water. How many pounds of 50% water-wettable DDT powder are needed?

$$Q = \frac{2.5\% \times 100 \text{ gallons} \times 8 \text{ lbs./gal.}}{50\%} = 40 \text{ lbs. of 50\% water-wettable DDT, and}$$

add water to make up 100 gallons.

4. Dilution Formula for pound to gallon preparations:

$$Q = \frac{S \times A \times D}{CO \times W}$$

Q = Quantity of concentrate required in gallons. S = Strength or percentage of active ingredient in the finished spray. A = Amount of spray to be prepared in gallons. D = Density: weight of gallon of diluent, usually water. CO = Concentrate: percentage of active ingredient. W = Weight of the insecticide concentrate in pounds per gallon.

Example: Prepare 100 gallons of 0.5% DDT emulsion from DDT concentrate containing 4 pounds per gallon. How many gallons of 4 lbs./gal. concentrate are needed assuming water weighs 8 lbs./gal. ?

$$Q = \frac{0.5\% \times 100 \text{ gals.} \times 8 \text{ lbs./gals.}}{100\% \times 4 \text{ lbs./gals.}} = 1 \text{ gal. of 4 lbs./gal. DDT concentrate,}$$

and add water to make up 100 gallons.

Chart 2

Insecticidal Residual Spray Formulae

5.0%	DDT Solution (by wt.)	is made up with	17.5	lbs.	technical DDT	+	50 gals.	diesel oil or kerosene
2.0%	Chlordan Solution (by wt.)	" " " "	1.0	lb.	technical chlordan	+	7.4 gals.	deodorized kerosene
2.5%	Chlordan Solution	" " " "	8.75	lbs.	technical chlordan	+	50 gals.	"
2.5%	DDT Suspension	" " " "	2.1	lbs.	50% wettable DDT	+	5 gals.	water
1.0%	DDT Suspension	" " " "	0.83	lb.	" " "	+	5 gals.	water
0.25%	DDT Suspension	" " " "	2.1	lbs.	" " "	+	50 gals.	water
0.125%	Chlordan Suspension (for outdoor ants)	" " " "	1.0	lb.	50% wettable chlordan	+	50 gals.	water
0.3%	Lindane Suspension	" " " "	5.0	lbs.	25% wettable lindane	+	50 gals.	water
0.5%	Lindane Suspension	" " " "	8.3	lbs.	25% wettable lindane	+	50 gals.	water
	Chlordan Emulsion (for ant control)	" " " "	2 to 4	tsp.	47% lindane emulsion concentrate	+	1 gal.	water
0.3%	Lindane Emulsion	" " " "	0.3	qt.	20% lindane emulsion concentrate	+	5 gals.	water
0.5%	Lindane Emulsion	" " " "	0.3	qt.	20% lindane emulsion concentrate	+	1 gal.	water

35% DDT Emulsifiable Concentrate
125 lbs. technical DDT
31.5 lbs. xylene (commercial grade)
1.0 gal. emulsifier (Triton X-100)
(good at 51°F. or above; produces 41 gals.)

25% DDT Emulsifiable Concentrate
82 lbs. technical DDT
31.9 gals. xylene
3.15 qts. emulsifier (Triton X-100)
yields 40 gals.)

25% DDT Rosin Emulsion Concentrate
105 lbs. technical DDT, dissolved in
36 gals. Xylene,
add and mix
1 gal. emulsifier (Triton X-100),
break up and mix
42 lbs. pine gum rosin
yields 50 gals. of concentrate with 10% rosin)

47-49% Chlordan Emulsifiable Concentrate (by wt.)
4.0 lbs. technical chlordan
0.6 gals. kerosene
0.6 lb. emulsifier
(each qt. contains 1 lb. of chlordan)

50% Chlordan Emulsifiable Concentrate (by vol.)
6.6 lbs. technical chlordan
0.3 gals. kerosene
1.6 lbs. emulsifier
(5 gals. of this concentrate, diluted to give good coverage, will treat 33 acres at the rate of 1 lb. per acre.)

Chart 2 (continued)

Larvicide Formulae

DDT in 0.625% Solution

2.5 lbs. technical DDT
50 to 55 gals. diesel oil or kerosene
(1 quart contains 0.05 lb. DDT)

DDT in 1% Solution

3.5 lbs. technical DDT
50 gals. diesel oil or kerosene

Benzene Hexachloride Residual Larvicide
1 lb. technical BHC (12% gamma isomer)
76 c.c. triton X-155 (or equal)
xylene to make up 1 gal.
(Use 1 gal. of concentrate per acre, dilute for good coverage)

Insecticide Vaporizers; If lindane or mixtures of it with DDT be used in insecticide vaporizers, the method and rate of dispersal should conform to the following:

1. The insecticide should be continuously released over a 24-hour period at the rate not to exceed 1 gram per 15,000 cubic feet per 24 hours. Devices should be so constructed that it would be impossible for the dispensing rate per hour to very more than 25%.
2. Installations should be made only in commercial or industrial premises, and similar locations where human exposure will be limited to a working-day basis and not continuous.
3. The devices should not be used in homes or sleeping quarters.
4. Insect vaporizer's should not be used in rooms or areas where food is served, processed, or stored.
5. Thus far, no evidence exists that other insecticides when used in vaporizers in space occupied by humans or where food is present are effective or safe.

Single service vaporization, sometimes called fumigation, has been found effective against exposed insects that are susceptible to lindane. This treatment may be made by releasing 1 gram of lindane per 1,000 cubic feet of enclosed space over a release period not to exceed 2 to 4 hours. A maximum dosage of 1 gram per 750 cubic feet may be permitted. A treated space must be closed and no occupancy permitted for 24 hours, after which, it must be thoroughly aired. Such a treatment should be restricted to not more than one application every two weeks. This treatment can be expected to give limited control of household insects.

Control of the house fly.

The house fly, Musca domestica, has long been known to be a carrier of many diseases. Among the most important are dysentery, cholera, typhoid, infantile or summer diarrhea, pink eye, tuberculosis, poliomyelitis, smallpox. Besides these there are probably about 25 more diseases which may be transmitted by this vector, including some intestinal parasitic worms. Other flies, smaller than the house fly known as the "lesser house fly" or "latrine fly" (Fannia canicularis or Fannia scaleris) breed in excreta, in fermenting and decaying garbage and are habitatious. Although less important, they may also carry the same diseases as the house fly.

Habits and characteristics. The house fly does not bite, although it is sometimes confused with the stable fly which is a vicious biter. The adult house fly is about 1/4 inch long, mouse gray or buff in color, the male being a little smaller than the female. While the eyes of the male are close together, those of the female are set more widely apart. The body, including the legs, is covered with hairs. Each leg is provided with a pair of pads studded with closely set hairs which enable the fly to walk on highly polished surfaces without slipping and to perambulate over a ceiling upside-down with a sublime contempt for the forces of gravity. These sticky hairs hold to germs as well as to highly polished surfaces. Its anatomic structure prohibits it from eating solid matter larger than 0.045 mm. in diameter. Perched on a lump of sugar, the fly may, indeed, seem to be eating forthwith: but if watched closely it will be seen to be dissolving the sugar by depositing saliva on it. The sugary solution is then sucked up through the proboscis and is frequently regurgitated

in a single drop, which is again sucked up. The fly may then retire to a quiet spot to clean its head and proboscis, to digest and alternately to vomit and such up its half digested food. This usually contains disease germs, and a second fly may not be too dainty to refuse what the first fly leaves of half digested food on the spot. It is omnivorous but not recklessly and indiscriminately omnivorous. In a pinch, it will eat anything and everything, provided it is soluble, but there is a definite grading of preferences for various eatables. Any decaying animal or vegetable material may serve as pabulum.

The most important breeding places of flies in order of importance are (1) Fresh horse manure, (2) human excreta, (3) manure of other animals than the horse, (4) garbage, (5) decaying fruits and vegetables, (6) rubbish dumps containing organic wastes, (7) ground where liquid wastes are spilled.

The house fly conveys disease germs not only on its legs but also in its digestive system through which many germs pass without being killed. The fly's habit of voiding its digestive tract while feeding is particularly conducive to the contamination of human food. It has been calculated that a fly which has access to abundant food produces between fifteen and thirty "vomit spots" and fecal deposits in twenty-four hours. The house fly is a creature of disgusting and dangerous habits, no more to be tolerated inside our dwellings and provision shops, or upon our meal tables, than a plague-stricken rat.

Life cycle The eggs of the house fly are oval, white, glistening bodies about 1 mm. in length. The number of eggs a single fly lays is between 1,000 and 3,000 which are layed in clusters of 100 to 150 at a time. Under favorable conditions, as many as 20 batches may be layed by one fly. Normally, 2 to 4 batches are layed in a life time. As there may be from 10 to 12 generations in one season, the number of flies for which a single female may be held responsible at the end of the season reaches astronomical proportions. Fortunately it is not the potential reproductive power of the fly that determines its numbers, but such considerations as the available food supply, climatic conditions and natural enemies. The eggs usually hatch out in about 12 hours, but when moisture is adequate, the egg stage varies in time – 8 hours at temperature between 85-90 degrees F., 24 hours at 60-68 degrees F., and 2 to 3 days at 40 degrees F.

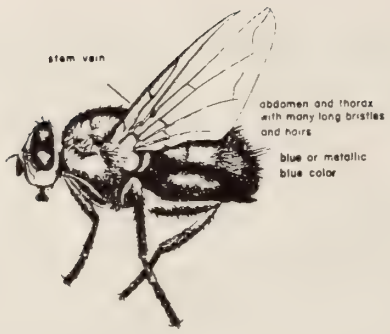
The larvae or maggots are grayish or creamy white, segmented like a worm, smooth and cylindrical and about 1/2 inch long. Being legless, they make their way by alternately contracting and expanding their bodies. During the larval stage, which usually lasts from 4 to 7 days, they are highly motile and burrow into a fermenting mass, feeding voraciously and growing rapidly. They grow by successive moults. The optimum temperature for growth is about 90 degrees F., and they are quickly killed at 115 degrees F., or if the material be wet, they are killed at 108 degrees F. At the end of this stage, they become restless and migrate from their feeding ground in search of cooler and dryer surroundings such as loose soil or under surfaces of stones and boards, in which to turn into the pupa stage.

The pupal shell is a mahogany brown, more or less barrel shaped, and developed from the contraction and thickening of the larval coating. It is about 6 mm. long, and is immobile. The length of the sojourn in this stage depends on the temperature. In midsummer, this stage lasts only from 3 to 6 days, but in cold weather it may be as long as 5 months. On emerging from the puparium, the new born, adult fly escapes from obscurity of its chrysalis hiding place and for a short while crawls about tentatively until its wings have expanded fully and hardened, and its body has accustomed itself to its new surroundings. With wings fully unfurled, the fly takes to the air and, although it usually remains near the place of its birth, it may fly several miles when food is scarce. Normally, the flight will not exceed 500 to 1000 yards. Most flies fly no more than 200 to 300 yards. Flies have been caught as far as 13 miles from their starting point when carried by the wind.

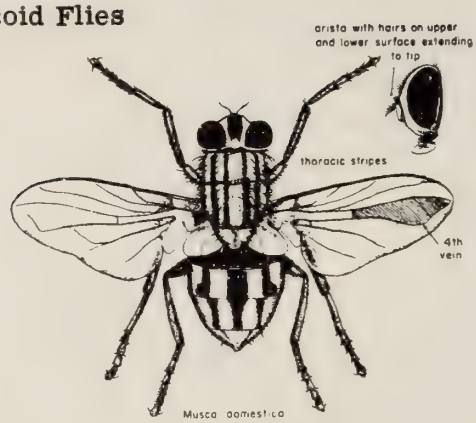
The house fly never grows larger than its size when it emerges from the pupal stage. It reaches sexual maturity and begins to lay eggs in from 2 1/2 to 20 days after emergence. Eggs are deposited by means of a small rod, projecting from the under surface of the female fly, deep in a crevice of a dung heap or other material where heat generated by fermentation facilitates hatching and where moisture prevents drying. Female flies like to deposit their eggs in company. This concerted effort may yield a cupful of eggs from a fresh manure heap. The female fly scorns stale horse manure.

Fig. 1

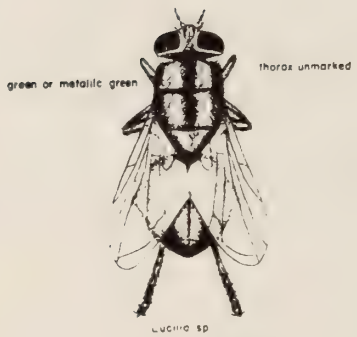
Muscoid Flies



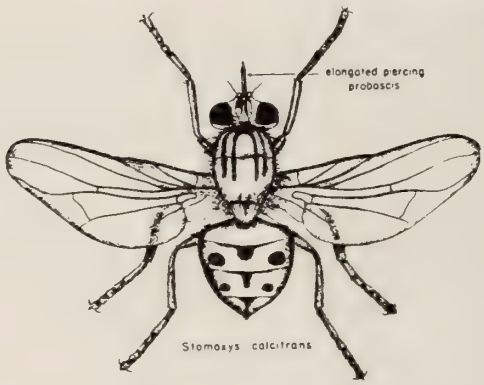
Blue Blow Fly



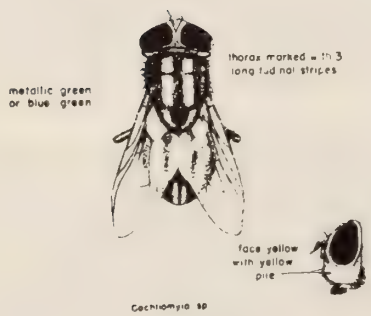
House Fly



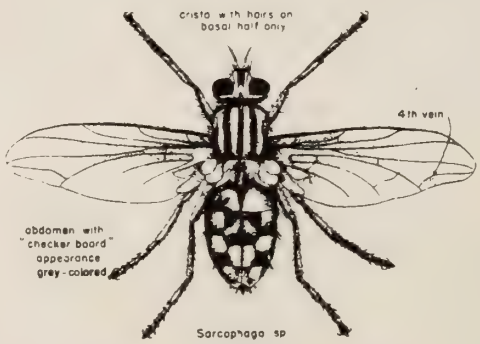
Green Blow Fly



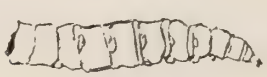
Stable Fly



Screw Worm Fly



Flesh Fly



House Fly Larva

House Fly Pupa

Fig. 2

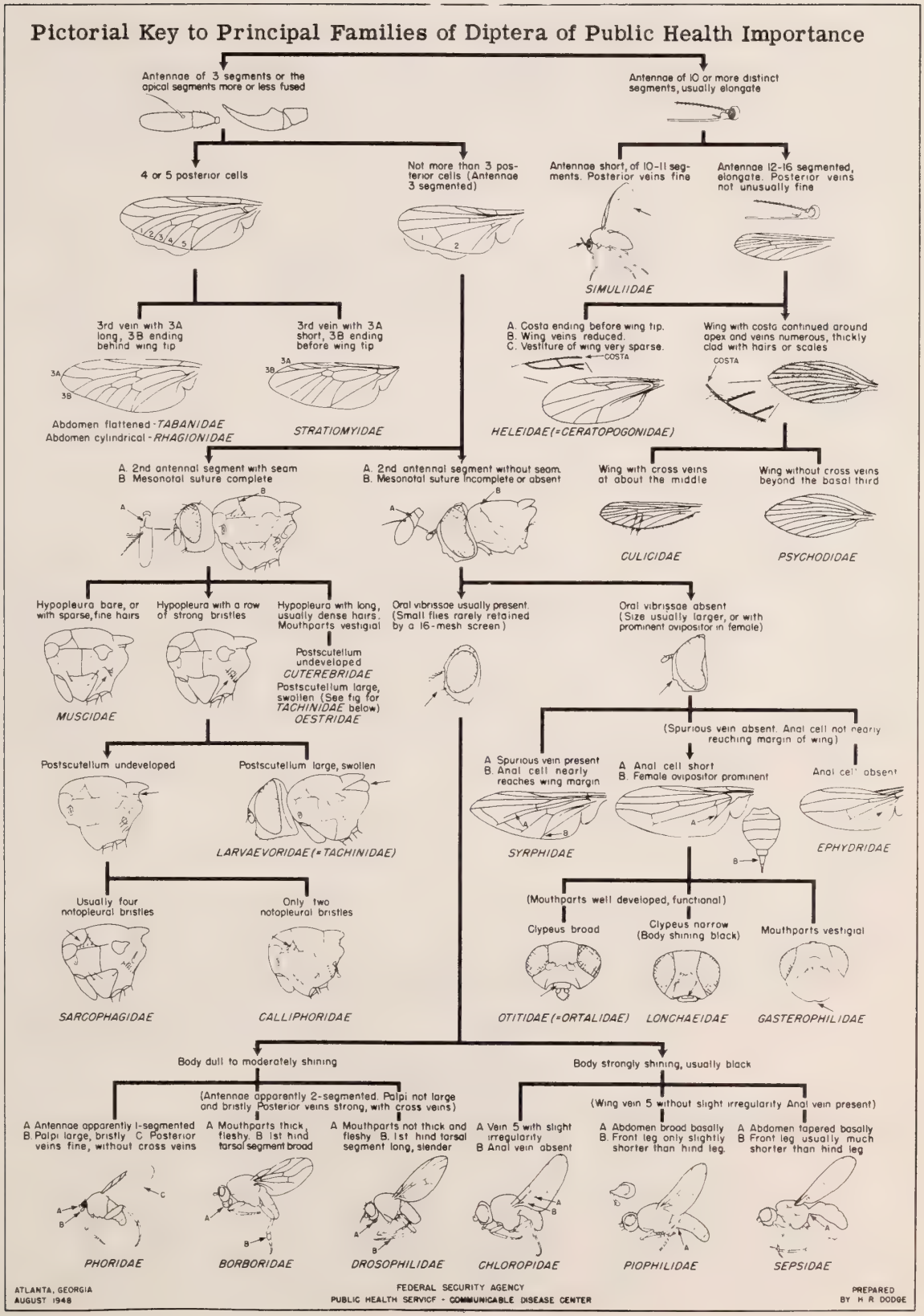
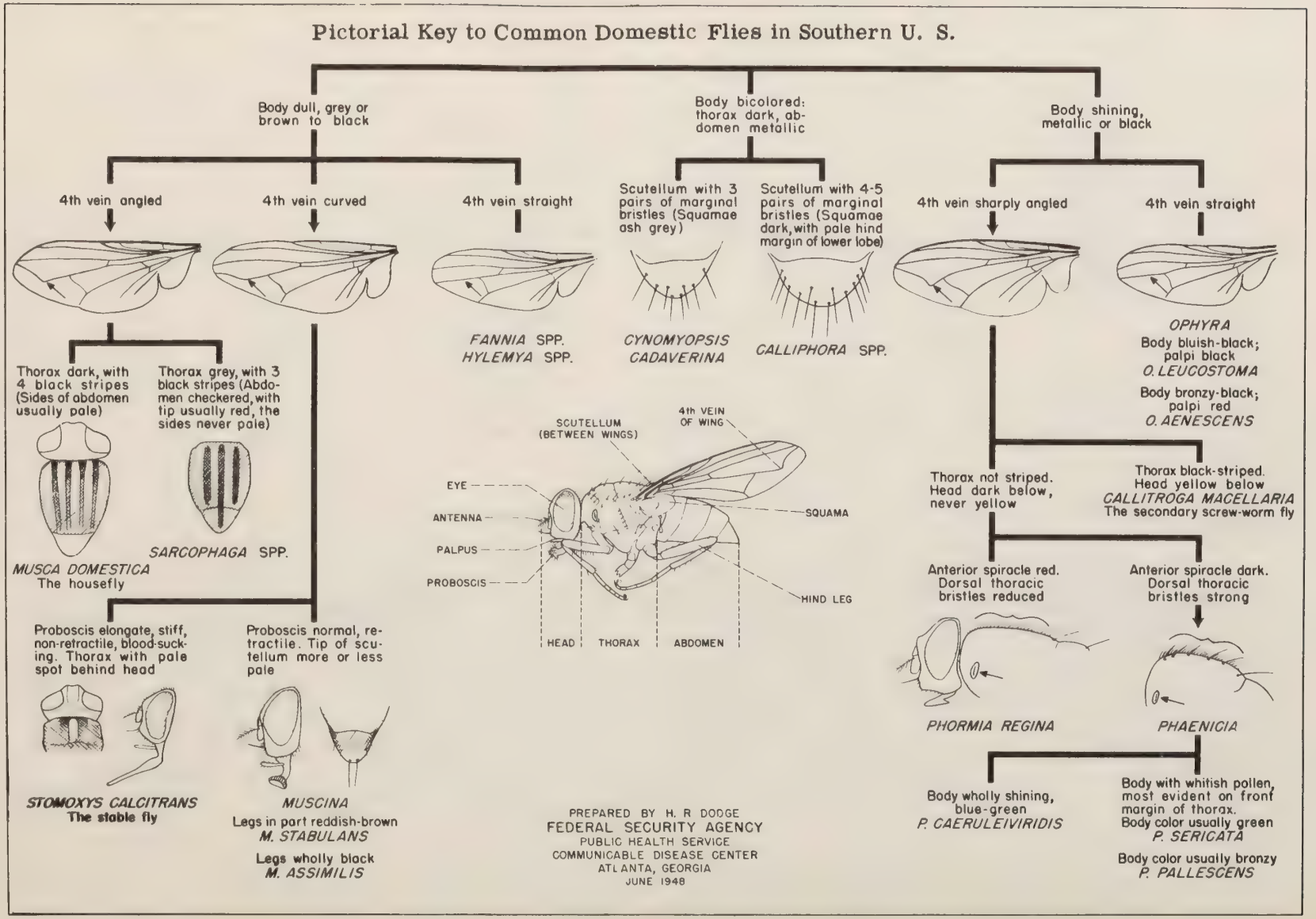

Pictorial Key to Principal Families of Diptera of Public Health Importance
Antennae of 3 segments or the apical segments more or less fused
Antennae of 10 or more distinct segments, usually elongate
4 or 5 posterior cells
Not more than 3 posterior cells (Antennae 3 segmented)
Antennae short, of 10-11 segments. Posterior veins fine
Antennae 12-16 segmented, elongate. Posterior veins not unusually fine
SIMULIIDAE
3rd vein with 3A long, 3B ending behind wing tip
3rd vein with 3A short, 3B ending before wing tip
A. Costa ending before wing tip.
B. Wing veins reduced.
C. Vestiture of wing very sparse.
Wing with costa continued around apex and veins numerous, thickly clad with hairs or scales
Abdomen flattened - TABANIDAE
Abdomen cylindrical - RHAGIONIDAE
STRATIOMYIDAE
HELEIDAE (=CERATOPOGONIDAE)
A. 2nd antennal segment with seam
B. Mesonotal suture complete
A. 2nd antennal segment without seam.
B. Mesonotal suture incomplete or absent
Wing with cross veins at about the middle
Wing without cross veins beyond the basal third
CULICIDAE
PSYCHODIDAE
Hypopleura bare, or with sparse, fine hairs
Hypopleura with a row of strong bristles
Hypopleura with long, usually dense hairs. Mouthparts vestigial
Oral vibrissae usually present. (Small flies rarely retained by a 16-mesh screen)
Oral vibrissae absent (Size usually larger, or with prominent ovipositor in female)
MUSCIDAE
Postscutellum undeveloped
CUTEREBRIDAE
Postscutellum large, swollen (See fig for TACHINIDAE below)
OESTRIDAE
(Spurious vein absent. Anal cell not nearly reaching margin of wing)
Postscutellum undeveloped
Postscutellum large, swollen
A. Spurious vein present
B. Anal cell nearly reaches wing margin
A. Anal cell short
B. Female ovipositor prominent
Anal cell absent
LARVAEVORIDAE (=TACHINIDAE)
SYRPHIDAE
EPHYDRIDAE
(Mouthparts well developed, functional)
Usually four notopleural bristles
Only two notopleural bristles
Clypeus broad
Clypeus narrow (Body shining black)
Mouthparts vestigial
SARCOPHAGIDAE
CALLIPHORIDAE
OTITIDAE (=ORTALIDAE)
LONCHAEIDAE
GASTEROPHILIDAE
Body dull to moderately shining
Body strongly shining, usually black
(Antennae apparently 2-segmented. Palpi not large and bristly. Posterior veins strong, with cross veins)
(Wing vein 5 without slight irregularity. Anal vein present)
A. Antennae apparently 1-segmented
B. Palpi large, bristly
C. Posterior veins fine, without cross veins
A. Mouthparts thick, fleshy.
B. 1st hind tarsal segment broad
A. Mouthparts not thick and fleshy
B. 1st hind tarsal segment long, slender
A. Vein 5 with slight irregularity
B. Anal vein absent
A. Abdomen broad basally
B. Front leg only slightly shorter than hind leg.
A. Abdomen tapered basally
B. Front leg usually much shorter than hind leg
PHORIDAE
BORBORIDAE
DROSOPHILIDAE
CHLOROPIDAE
PIOPHILIDAE
SEPSIDAE
ATLANTA, GEORGIA
AUGUST 1948
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE - COMMUNICABLE DISEASE CENTER
PREPARED BY H. R. DODGE

Fig. 3


Pictorial Key to Common Domestic Flies in Southern U. S.
Body dull, grey or brown to black
Body bicolored: thorax dark, abdomen metallic
Body shining, metallic or black
4th vein angled
4th vein curved
4th vein straight
Scutellum with 3 pairs of marginal bristles (Squamae ash grey)
Scutellum with 4-5 pairs of marginal bristles (Squamae dark, with pale hind margin of lower lobe)
4th vein sharply angled
4th vein straight
FANNIA SPP.
HYLEMYA SPP.
CYNOMYOPSIS CADAVERINA
CALLIPHORA SPP.
OPHYRA
Body bluish-black; palpi black
O. LEUCOSTOMA
Body bronzy-black; palpi red
O. AENESCENS
Thorax dark, with 4 black stripes (Sides of abdomen usually pale)
Thorax grey, with 3 black stripes (Abdomen checkered, with tip usually red, the sides never pale)
SARCOPHAGA SPP.
MUSCA DOMESTICA
The housefly
SCUTELLUM (BETWEEN WINGS)
4th VEIN OF WING
EYE
ANTENNA
PALPUS
PROBOSCIS
SQUAMA
HIND LEG
HEAD
THORAX
ABDOMEN
Thorax not striped. Head dark below, never yellow
Thorax black-striped. Head yellow below
CALLITROGA MACELLARIA
The secondary screw-worm fly
Anterior spiracle red. Dorsal thoracic bristles reduced
Anterior spiracle dark. Dorsal thoracic bristles strong
Proboscis elongate, stiff, non-retractile, blood-sucking. Thorax with pale spot behind head
Proboscis normal, retractile. Tip of scutellum more or less pale
PHORMIA REGINA
PHAENICIA
STOMOXYS CALCITRANS
The stable fly
MUSCINA
Legs in part reddish-brown
M. STABULANS
Legs wholly black
M. ASSIMILIS
Body wholly shining, blue-green
P. CAERULEIVIRIDIS
Body with whitish pollen, most evident on front margin of thorax.
Body color usually green
P. SERICATA
Body color usually bronzy
P. PALLESCENS
PREPARED BY H. R DODGE
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
COMMUNICABLE DISEASE CENTER
ATLANTA, GEORGIA
JUNE 1948

It must not be more than a day old. As a rule, eggs are layed in a manure heap within the first 8 hours, and once the eggs have hatched out from such manure, a new batch will not be layed unless fresh manure be added. Knowledge of this fact dispels the common notion that old manure heaps breed flies.

The length of life of the house fly is about 1 month. In the United States, breeding begins in May in northern states and April or March in southern states. Their number is usually greatest in August and September and rapidly decreases as the cooler weather sets in. In the fall, many are killed by parasitic diseases caused by fungi. They are rendered inactive by cold and are killed by exposure to a temperature between 10 and 15 degrees F. The adult does not survive the winter months, but hibernates in the larval or pupal stage. They may also breed continuously during the winter months if allowed to remain in a warm house where adequate food is available.

Control. The principal habits and characteristics of the house fly which form the rationale for control measures are:

1. The preference for horse manure as breeding material and the tendency to breed freely in horse and other animal manure, human excreta, and fermenting vegetable wastes.
2. The necessity for moisture, warmth, and soluble food for normal development of larvae.
3. The susceptibility of the larvae to temperature of from 110 to 115 degrees F.
4. The tendency of the mature larvae to migrate from the breeding material prior to pupation.
5. The development of the pupa at or beyond the borders of the mass of breeding material.
6. The ability of the larvae and the adult insect to crawl through loose manure or earth.
7. The attraction of adult flies to food by odor.
8. The tendency of flies to fly toward light.
9. The tendency of flies to rest on vertical surfaces or hanging objects.

The continuous application of measures which will prevent fly breeding are, as a rule, less expensive and more effective than sporadic attempts.

Disposal of manure. Sanitary disposal of manure is important in controlling fly breeding, and for esthetic reasons.

The amount of manure produced varies somewhat with the method of caring for the animals. Where animals are kept on a picket line without bedding, they produce an average of 10 pounds per animal per day. If animals be stabled, the manure and bedding to be disposed of daily will average from 2 to 3 cubic feet per animal per day.

Methods of disposal are: (1) by contract, (2) spreading on fields as fertilizer, (3) drying, (4) incineration, (5) composting.

Disposal by contract: The important consideration here is that the manure should be collected and transported in such manner as not to produce a fly breeding hazard, and that the contractor uses and distributes the manure without creating the aforementioned hazard. The collection and transportation should be carried out with the following rules in mind:

1. The manure should be collected early in the morning of every day.
2. All manure should be completely carried away.
3. The vehicles should not allow spillage.

Disposal of manure as fertilizer. Fresh manure should be finely divided and spread thinly on ground in order that it should dry quickly. If conditions be such that drying quickly is not possible, the manure should be plowed under.

Disposal by drying. This is feasible only in dry climates. Ground to be used should be tamped and cleared of vegetation. The manure is spread in a layer not over 1 to 2 inches thick. All lumps are broken. Four days to a week are required to dry manure, therefore 4 to 7 areas for drying should be selected. Four to 12 square feet of area are required for 1 animal per day. This manure can be used to fill low areas, burned, or stacked away for future use. If it becomes wet it will serve as a fly breeding place.

Incineration of Manure. It may be stacked in long windrows, sprayed with oil and burned. If dried it can be burned without oil. An open incinerator can be used for burning manure.

Disposal by composting. When manure is closely packed in a heap, the heat generated by fermentation will kill fly larvae. In this manner it can be stored until ready for use as fertilizer. In composting manure, a temperature of 140°F. to 160°F. is reached at depths of more than 8 inches to 1 foot from the surface, while a temperature of 115°F. is sufficient to kill house fly larvae in a few minutes. Manure is usually infected with fly eggs when placed in compost pile. After a period of fermentation of the organic matter for about 2 months, mineralization occurs, the soluble constituents drain away, and the manure no longer serves as a breeding place for flies. The larvae that do develop in the outer layer of the pile, tend to migrate to cooler, dryer places when they mature and get ready to pupate. The larger number migrate between the sixth and tenth day after the pile is laid, but some continue to migrate for about a month. If it be used as a fertilizer before fermentation ceases it may become a source of fly breeding. The fermentation process reduces the fertilizing value of the manure to some extent.

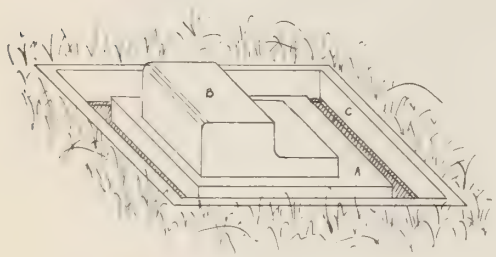


Fig. 4

Legend for Fig. 4

A. Compost pile platform, denuded of grass, tamped down, sprayed with crude or waste motor oil - or made of concrete for permanent use.
B. Compost pile, packed firmly. Heat inside pile drives larvae to surface, sides kept as vertical as practical.
C. Trench - 6 inches to 1 foot deep; vertical sides lined with water proof material such as asphaltum or concrete. If soil be clay, tamping will make it sufficiently watertight. Ditch is supplied with 1 to 3 inches light crude oil or waste motor oil. Water may be used if oil be not available. This serves as a trap for larvae which seek to migrate to dryer, cooler environment.

In order to destroy the eggs and larvae in the outer layer, a six inch layer from the periphery is stripped at not more than 3 day intervals and buried in the depths of the pile. Other means such as spraying the pile with larvicide once or twice weekly will control larvae. DDT is not effective against the larvae. Larvicides used are:

1. If manure be not used as fertilizer: (a) Crude Oil, (b) Waste Oil, (c) Kerosene, (d) 2% solution of cresol (best), (e) Lindane, chlordan, benzene hexachloride, aldrin and dieldrin.
2. If manure be used as fertilizer:
   a. Borax solution: 1 pound borax to 4 gallons water; spray one quart per square foot of surface. Borax powder: dust on pile then wet; use one ounce per square foot of surface.
   b. Hellebore: 1 pound hellebore to 20 gallons of water; allow to stand 24 hours before using; spray one gallon to each square foot of surface.
   c. Iron sulphate: 2 pounds of chemical to 1 gallon of water; spray 1/2 gallon to each square foot of surface.

A similar technique as involved in the compost pile is carried on by packing manure tightly in a bin. Similar precautions should be taken.

It may be desirable to use larvicides for fly control in certain situations such as dirty garbage cans and privies or areas of concentrated fly breeding such as at stock yards or chicken farms. Several chlorinated hydrocarbons are effective fly larvicides, but the use of these may result in development of resistance in the same manner as encountered in relation to adulticides.

Dieldrin and aldrin have been effective as a 0.125% emulsion at the rate of 25 mg. per square foot. Lindane has been effective as a 0.625% emulsion at the rate of 25 to 50 mg. per square foot. These materials should be applied at the same dosages per square foot as recommended for residual sprays. In general, it appears desirable to dilute the residual spray emulsions or solutions three to five times their original volume in order to provide better penetration of the larvae breeding medium. The application of paradichlorobenzene (PDB) crystals at the rate of 2 oz. per garbage can has given control of fly breeding for 1 to 2 weeks. This should be used where flies are resistant to other types of larvicides. For blow-fly larvae infestation of carcasses of dogs, 1 pint

of 0.25% aldrin, endrin, or diazinon or malathion give protection for 26 to 30 days, or completely kill the maggots in already infested carcasses.

Current data suggest that the treatment of privies with dieldrin, chlordane, or BHC should be avoided since such practice tends to increase rather than decrease fly propagation in such sites.

Destruction of adult flies: The adult flies may be destroyed by the use of residual sprays, dusts, traps, fly paper, screening, and swatting. These are temporary measures and should not be used as a substitute for excreta, garbage, and waste control.

DDT. In most areas of extensive use of residual sprays, house flies have become highly resistant to DDT and in some instances to several other chlorinated hydrocarbons. In this case, the organophorphorus compounds, malathion or diazinon, should be tried. DDT, however, is still the insecticide of choice in areas where house flies remain susceptible to it, except in dairy barns, milk rooms, rooms containing dairy feed, and other situations where its use may result in adulteration of milk. The U. S. Department of Agriculture advises that the use of DDT in and around dairies should be prohibited since it tends to accumulate in the fatty tissues of exposed animals and to be excreted in the fat of milk. It can sometimes be detected in small amounts in cow's milk following the use of this insecticide in dairy barns. It also urges that this insecticide not be applied to animals producing milk for human consumption. In the light of current information, the Bureau also advises that safer materials be used for insect control in places where milk might be adulterated. At present, at least, none of the chlorinated hydrocarbon insecticides is recommended for controlling insects on feed or forage crops that are to be fed to dairy animals except lindane or methoxychlor.

For killing adult flies a 5% emulsion or suspension applied at the rate of 4 milliliters of spray per sq. ft. of treated surface area is recommended for general use. Where outdoor treatments are required, the addition of pine gum rosin to give 2% rosin in the finished spray increases the residual effectiveness of the DDT. At least, a three month residual effectiveness may be obtained in this way.

DDT may be used in control of flies around food handling establishments. The residual spray method is used. In restaurants, the ceiling, walls and upholstery of dining rooms and kitchens may be sprayed.

In the homes, flies may be controlled by treating the back porch and steps and the area around the kitchen door. Food and water containers should be kept covered after spraying because flies may fall into them as DDT takes effect. The recommended formulae do not produce any disfigurement on a wide variety of paints and varnishes. Where the fly problem is not too great DDT impregnated strings suspended from the ceiling may be satisfactory. Wherever food is being handled, such as around canneries, grain and feed mills, dumps, garbage stations, garbage cans and adjacent surfaces, and the like, good control is affected with a 2 1/2% DDT emulsion spray. Platforms, alleys (allowing good penetration of DDT emulsion between the bricks), railroad loading areas, floors, and any place where spilled foods may accumulate are treated at the rate of 200 mg. per square foot at intervals of three weeks.

The principal resting places of flies should be covered with the spray residue. At night they prefer to rest on ceilings, around cracks and crevices, along edges of ceilings, doorways, and furniture. Electric and switch cords should be painted or sprayed with DDT solution. When flies cling to them, they receive a toxic dose of DDT. Under ordinary conditions, it is not necessary to treat all rooms. In some places, fly control can be accomplished merely by spraying these special places without treating the entire room.

A small hand sprayer, a larger air-pressure garden sprayer, or a wide paint brush are suitable for treating the walls and ceilings of rooms where food is prepared or served.

In situations where flies have become resistant to residual sprays, an effective alternative is selective treatment of night-time resting places of flies with space sprays. In urban areas, house flies and the more common blowflies generally rest at night in the lower branches of trees, and in bushes, grasses and weeds. During cool weather, house flies tend to seek the protection of out-

buildings. In rural areas, the inside of unscreened dwellings is a favorite resting place. On premises with screened dwellings, the flies rest on porches and in animal shelters during cool weather, and in lower tree branches and shrubs in warm weather (70°F. and above). Local surveys should be made as a guide to determining the nocturnal resting places.

Combinations of DDT with the synergist DMC at ratios ranging from 5:1 to 20:1 (particularly 7.5:1 of DDT:DMC) have given effective kills when applied as space sprays against strains of flies resistant to several chlorinated hydrocarbons. Emulsions or fuel oil solutions of this combination, using 5% DDT, are recommended as space sprays for fly control. Other DDT-synergist combinations are under investigation.

Chlordan (2.5% emulsion) is recommended as a space spray and for selective spot treatment inside dwellings or buildings, and a 5% emulsion for treating porches and other outside locations relatively protected from weather in areas where flies have not yet become resistant to this insecticide. For extensive outside spraying, 2.5% emulsion is applied at the rate of 0.2 lb. chlordane per acre.

Dieldrin, applied as a 0.625% or 1.25% emulsion, is recommended as an outdoor residual spray for use by trained personnel in organized fly control programs in areas where DDT-resistant flies may still be susceptible to this compound.

Dilan in 2.5% to 5% suspensions in water is recommended as a residual spray for fly control, but flies quickly develop resistance to it. It is also recommended as an outdoor space spray against DDT-resistant flies in the form of 2.5% emulsion and at the rate of 0.1 lb. of dilan per acre.

Indications are that the emulsion formulation dilan - 5 parts, DDT - 5 parts, cotton-seed oil - 4 parts, sprayed at the rate 200 mg. of dilan, 200 mg. of DDT, and 80 mg. of cotton-seed oil per square foot has controlled DDT-resistant flies for periods of 5 to 8 weeks.

Lindane applied at the rate of 25 mg. per square foot, or methoxychlor at 200 mg. per square foot, is recommended for use in dairy barns, feed barns, and other situations where the use of other chlorinated hydrocarbons might result in adulteration of milk. But neither of these may be expected to give the degree of control originally achieved with DDT residuals, and lindane should not be applied directly to dairy animals, animal foods, water nor to equipment used in feeding and watering animals. Methoxychlor at the rate of 2 quarts or 0.5% suspension may be applied directly to animals. Because of its low chronic toxicity, lindane has been used quite extensively in dairies, restaurants, etc. as an insecticidal vapor. It may be formulated as wettable powders, dusts, solutions, and emulsifiable concentrates, or volatilized vapors. For summer use the following concentrate is satisfactory:

Lindane	1 2/3 lb.
Triton X-155, or equal	76 c.c.
Xylene to make up	1 gal.

This concentrate should be diluted 1 part to 31 parts water to give the desired 0.625% finished emulsion. This will give a residual deposit of 25 mg. per square foot when applied in the usual manner of residual spraying. A 2% lindane or 5% technical BHC (12% gamma isomer) emulsion is effective as a space spray against house flies resistant to DDT, Chlordan, dieldrin, and other chlorinated hydrocarbons.

Organophosphorus compounds. Toxicants of this nature have been developed, such as malathion and diazinon, which permit their safe usage as residual spray against resistant fly and mosquito populations in strengths of 1 to 2.5%. It is, however, desirable that individuals engaged in routine application of these toxicants be checked periodically on their cholinesterase levels. Addition of sugars to malathion emulsion definitely augments its residual efficacy. Sugar is added in the proportion of 2.5 parts of sugar to 1 part of malathion. Experimental barns treated with a diazinon-sugar formulation at the rate of 100 mg. of toxicant with 250 mg. of sugar per square foot of surface showed excellent control of house flies for a period of 4 to 5 weeks. Malathion-sugar emulsions applied at rates of 200 mg. of malathion and 500 mg. of sugar per square foot also gave excellent house fly control for 4 to 5 weeks. Cords impregnated with a 25% diazinon-xylene solution and suspended from the rafters of barns have given excellent housefly abatement for approximately

Chart 3. - Use of Chemical Sprays for Fly Control

Purpose	Where applied	Chemical	Concentration (percent)	Mixing procedures	Dosage Rate	Remarks
To control horn-flies and stable-flies	Directly to cattle	Methoxychlor	0.5	Mix 4 pounds 50 percent powder with 50 gallons water. Agitate	2 quarts/ animal	May be effective for 1 to 4 weeks
To control house-flies and stable-flies inside dairy barns	To interior walls, ceilings, and other surfaces where flies rest	Lindane	0.3	Mix 1/2 pound 25 percent powder with 5 gallons water or 10 fluid ounces emulsifiable concentrate with 5 gallons water. Agitate	1 gallon/ 500 square feet.	Effective 2 to 4 weeks. Not to be used on dairy cattle
		Methoxychlor	2.5	Mix 2 pounds 50 percent powder with 5 gallons		
To control house-flies, stable-flies, and blow-flies resting outside dairy barns	As fine mist directed at flies	Pyrethrum-Piperonyl butoxide	0.1 and 1.0	Use commercial product	As required	Must be repeated at frequent intervals
	To exterior walls surfaces, sheds fences, vegetation	DDT	5.0	Dilute 25 percent concentrate at rate of 1 part to 4 parts water.	1 gallon/ 1,000 square feet.	Add rosin to emulsion for greater effectiveness out-doors. Do not spray on cattle, or inside dairy barns.
			2.5	Mix 2 pounds 50 percent powder with 5 gallons water.	1 gallon/ 500 square feet.	
		Chlordan	5.0	Dilute 1 part 40 percent concentrate with 7 parts water or 1 part 46 percent concentrate with 8 parts water.	1 gallon 1,000 square feet.	To be used where flies are resistant to DDT. Do not use inside dairy barns or on cattle
To control larval (Maggot) stage of flies	To manure or other fly-breeding media	Chlordan	1.0	Dilute 1 part 40 percent concentrate with 39 parts water or 1 part 46 percent concentrate with 45 parts water.	As required	Wet surface of breeding medium thoroughly. Repeat weekly until flies are under control.
		Benzene Hexachloride	.125	Mix 1 pound of wettable powder in 50 gallons water. Agitate	As required	

7 weeks. Cotton cord 3/32 of an inch in diameter is used. The cords are dipped and dried, and then hung at a rate of 30 linear feet of cord per 100 square feet of floor area. Parathion (5 to 10%) dipped cords give longer periods of control than diazinon, but it is one of the very toxic organophosphorus compounds. Dipped cords should be colored for identification.

Pyrethrins. Pyrethrum powder is effective in paralyzing the flies. Doors and windows of room must be closed and larger incidental openings closed. Powder is sprayed with a dust blower until the air is heavily charged. After 1 hour the room is opened, flies are swept together, and burned.

Natural pyrethrins in combination with synergists are the least toxic and very reliable for outdoor and indoor space sprays. Synthetic pyrethrins are almost as effective as pyrethrum for space spray and are used in emulsions or oil solutions containing from 0.05 to 0.1% pyrethrins and 0.5 to 1.0% synergist. The insecticidal power of pyrethrum is increased by adding one ounce of oil of pennyroyal or citronella to 1 gallon pyrethrum extract.

Kerosene containing 5% citronella is useful. Derris root powder may be used in place of pyrethrum and is extracted with kerosene in the same manner as pyrethrum. Rotenone is the active principle of derris root.

Fly trapping. The success of fly trapping depends upon constant and efficient supervision and the use of properly constructed traps and suitable baits. This method of destruction utilizes two habits of the fly, namely: (1) The tendency to fly toward light, (2) Their attraction to food by odor rather than sight.

Fly traps vary in design and size, but all of them consist of two main parts: (1) The bait chamber, (2) The trap chamber. The bait chamber is the lower, darker part of the traps into which the flies are enticed by the odor of the bait. The trap chamber is the upper and lighter part and is connected with the bait chamber by an aperture through which the flies crawl toward the light after having fed on the bait. The tendency of the house fly to fly or crawl toward the light prevents it from passing back into the bait chamber and escaping from the trap.

The structural characteristics of the fly traps are as follows (See figure 5):

1. The size is such as can easily be manipulated. Therefore they should probably not be more than 18 inches square or 24 inches high.
2. They may be made of all screen mounted on a frame or some of the sides may be made of solid wood.
3. The screen used is 16 to the inch mesh metal screening.
4. The aperture leading from the bait to the trap chamber is about 1/4 to 1/2 inch in diameter.
5. The bottom of the traps stand off the ground about an inch to allow the flies to reach the bait.
6. An opening should be provided for the trap through which the dead flies can be emptied.

Location of Fly Traps.

1. Near breeding places, such as manure piles, latrines, garbage cans and dumps.
2. Near kitchens, around entrances to buildings where food is prepared or served.
3. On the lee side of buildings in order to be as much out of the wind as possible. Wind prevents flies from entering traps.

The traps are more effective if placed upon elevated stands, boxes, or benches. An ample number of traps should be used in order to obtain results.

Baits. Suitable fly bait must have an odor attractive for flies and should not constitute a nuisance because of the odor or appearance. It should be cheap and easily obtainable. The odor should be such as to freely diffuse through the air. Such material is usually putrefactive or fermented.

The putrefactive baits consist of spoiled raw meat or fish such as fish heads or canned salmon.

The fermented baits are those which contain alcohol or in which alcohol is formed. Usually they consist of a mixture of cereal, sugar or molasses, yeast and water which is allowed to ferment

before or while being used. Some baits are:

1. Corn Meal Bait is composed of:
   Cornmeal . . . . . 8 ounces (by volume)
   Molasses . . . . . 5 "
   Water . . . . . .16 "
   Yeast . . . . . .1/2 cake

This is prepared by mixing the water and the molasses and heating to boiling. While boiling, this mixture is poured over the cornmeal, stirred, and allowed to cool. The yeast is added then and allowed to stand exposed to the air for 3 or 4 days. Bran and cornstarch may be substituted for the cornmeal. Syrup made of sugar and water may be substituted for molasses.

2. Molasses . . . . . 2 parts
   Vinegar . . . . . 1 part
3. Molasses which has been allowed to stand exposed to the air for 3 or 4 days.
4. Crushed over-ripe bananas in milk.
5. Brown sugar and sour milk.

The efficiency of various baits are in order: putrefying meat, fermenting cornmeal or bran, molasses, and vinegar.

Poison baits of organic phosphorus compounds, such as malathion, Bayer L 13/59 (Dipterex-trade name) and diazinon, are finding extensive use for fly control. Liquid baits generally are composed of 0.1% toxicant and 10% attractant (molasses, sugar, or other). Application is at a rate of 1 gallon per 1000 square feet of floor area. If the floor surface be dirt or covered with debris the bait should be sprinkled on sacks or metal or wooden sheets. Dry baits contain 1 to 2% toxicant and an attractant such as granulated sugar or an inert carrier coated or mixed with an attractant. Dry baits are scattered on the floor at a rate of 2 to 4 ounces per 1000 square feet. General coverage of the floor area with either liquid or dry bait is not desirable. Sites of greatest fly concentration should be chosen. Frequency of application varies. At beginning, daily application for two weeks may be necessary, thereafter, once every 3rd or 4th day. The bait remains toxic for 1 to 2 weeks, but where floors are washed or swept each day, no residual can be expected.

Malathion or Bayer L 13/59 have given good results on dump areas against blow-flies and house- flies with formulations of 2% toxicant and 50% black strap molasses in water.

Baits of malathion and Bayer L 13/59 can be used in dairy barns, but diazinon baits should not be used therein. None of these baits should be used inside homes.

Care of Fly Traps: Liquid fly bait should be placed in wide, shallow containers from which volatile constituents of the bait are readily evaporated. There should be at least 3 inches between the edges of the bait pan and the edges of the trap. Two bait pans should be used in traps which are 18 inches in length or longer. Baits should be inspected once a day. Solid baits should not be allowed to dry out. Pans containing liquid bait should be kept filled to desired level. Liquid bait should be replaced when scum forms on surface. All baits should be kept free from dirt and dust. Empty the trap chamber often enough so no interference with light entering the chamber takes place. Flies may be killed by immersing the trap in water or stupifying the caged insects with sulfur gas or insecticide.

Fly paper and Fly wire: Flies may be caught in considerable numbers on wires or strips of paper coated with a sticky preparation. Fly mucilage is prepared:

1. Castor oil . . . . . 1 part
2. White rosin . . . . . 2 parts
3. Heat and stir until a homogeneous mass is obtained. (Do not boil.)

Fly wire consists of pieces of baling wire or fence or telephone wire made into pieces 18 to 36 inches long and bent into hooklet at one end. Several wires may be twisted together. The wires are passed through hot mucilage in a pan. Fly paper is prepared by applying a thin coat of hot mucilage to strips of paper 18 to 36 inches long and 1 or 2 inches wide. Ordinary wrapping paper or glazed paper is satisfactory.

In this case, advantage is taken of the tendency of the house fly to rest on hanging objects or vertical surfaces by hanging the wire or paper from ceiling or rafters. Do not hang these over places where flies may fall into food or on tables. Wires can be wiped off and re-coated. Paper when filled with flies is burned.

Fly Poison: Two poisons used are formalin (commercial formaldehyde) and sodium salicylate, because they are not poisonous or dangerous to man but are efficient as fly poison.

Formaldehyde Poison: Consists of 1.25 or 2.5% of formalin (40% formaldehyde) in water, or about 3 teaspoonfuls of formalin to a pint of water. Instead of using plain water for the dilution, use 50% lime water, or milk and 50% lime water since flies like alkaline solution. A small quantity of molasses added will increase its attractiveness for flies. Formalin poison should be freshly made.

Sodium Salicylate Poison: Consists of 1% sodium salicylate solution plus a small amount of brown sugar. This is made by dissolving 1 or 2 teaspoonfuls or powdered sodium salicylate and 1 teaspoonful of brown sugar in 1 pint of water. This is slightly less efficient than formaldehyde poison but is more stable.

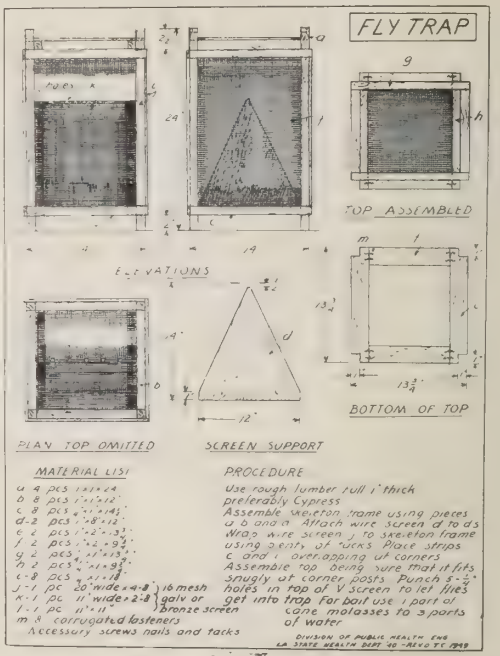


Fig. 5 Fly Trap

Poison solution is placed in shallow containers, a few pieces of bread are added to make place for the flies to alight. A piece of blotting paper may be placed in the containers with some sugar sprinkled on it.

Swatting: This is merely an accessory measure, but can give good results if used especially before a meal is served.

Screening: This does not reduce flies but it is the most important measure in preventing flies from gaining access to food. Consequently buildings should be screened as described in chapter on mosquito control. Flies can be excluded by the use of screens having a mesh of 16 wires to the inch, but such wire does not exclude mosquitoes. Therefore it is more practical to use an 18 mesh wire screen which will also exclude mosquitoes.

Control of Fleas.

Wherever men and such animals as dogs, cats, and rodents are concentrated, conditions are favorable for the development of fleas. Camps and other locations, including ships, where men congregate and where pet and stray dogs and cats occur, or where rats and mice forage in storerooms, provide ideal conditions in which flea populations increase. Fleas annoy man by biting. The rat fleas may transmit serious diseases to man such as typhus and plague.* The principal fleas which annoy or bite man are the cat fleas, Ctenocephalides felis, the dog flea, Ctenocephalides canis, and the human flea, Pulex irritans. The common rat flea of the United States and Europe, Nosopsyllus fasciatus, formerly known as Ceratophyllus fasciatus, is believed to be one of the most important agents in maintaining the reservoir of plague in rats and to be capable of prolonging rat epizootics when associated with X. cheopis. Its importance in transmitting disease to man is questionable. The oriental rat fleas found in most countries is Xenopsylla cheopis.* Cat and dog fleas breed on cats and dogs alike, and, when numerous or in the absence of the natural hosts, attack man. They breed on various other animals also. The cat and dog fleas are abundant in the eastern part of the United States, but are relatively scarce in the West. Human fleas attack man as well as dogs, cats, hogs, and other animals. They are annoying in buildings, stables, and surrounding premises, especially in the Middle West, South, and on the Pacific Coast where this species is the predominant one affecting man. It is chiefly important because of its vicious bite.

*Discussed in detail in chapter of Rodent Control.

In laboratory experiments it has transmitted plague, and its possible importance in this regard should not be overlooked. Rat fleas are found around burrows and nesting areas. These fleas leave rats that die from disease or poison. Therefore, flea control programs are carried on simultaneously with rat poisoning programs, lest the fleas that leave the dead rats seek man for their host.

In sub-tropical and tropical America, an additional pest is encountered. This is the "chigoe" flea known scientifically as Tunga penetrans. This should not be confused with the North American "chigger" which is a mite. The chigoe is responsible for ulcerated sores on the soles of the feet, under the toe nails, and between the toes. Other parts of the human body are occasionally attacked. Domestic animals, especially hogs, are hosts, and serve as a source of human infestation.

It is reported that during the East African Campaign in the first World War, this flea not only caused much suffering, but considerable loss of man power, due to its crippling effects.

"Chigoe" control includes ridding the premises of fleas and eggs, and treating domestic animals as outlined later in the case of other fleas. As a protection, shoes should be worn. Chigoes are removed from the body with a sterilized needle or knife-blade, and the open wound treated with an antiseptic.

Identification. Because of the similarity in appearance and habits of some of the species of fleas, it is impossible for anyone but a specialist to determine definitely what species are causing trouble. A specific identification may be obtained by sending specimens to the Bureau of Entomology and Plant Quarantine, Department of Agriculture, Washington, D. C. or to a similar agency of state government. Fleas should be dropped in vials containing 70% (ordinary rubbing) alcohol and forwarded with the name of the collector, place and date of collection, and host from which taken.

Biology. For breeding, all fleas must have access to warmblooded animals. Adult fleas lay their eggs in the fur or feathers of the animal host. These eggs drop off and lodge in the sleeping quarters of the animal, or in cracks in floors, out-of-doors on the ground, etc. The eggs hatch in a few days into larvae (small wormlike creatures) which subsist on the debris found on the floor or ground. In two weeks or more the larvae become full-grown and enclose themselves in tiny cocoons in which they transform to adult fleas in the course of a few days or longer. When the adult stage is reached, the new crop of fleas apparently "born hungry" become quite active in search of food, although they may subsist for weeks without nourishment. Fleas usually are unable to jump further than 6 inches. "Sand-flea" infestations are due to fleas hatched from eggs dropped from cats or dogs. The animals may have been away from the premises for a month or two, but the flea eggs remain and complete their development. Consequently, when a person enters a cellar, vacant building, or yard, he may be besieged by hundreds of voracious fleas which apparently have bred in the dust or sand.

The life history of the chigoe flea is an exception to that of the usual flea. The female attaches itself firmly by means of her mouth-parts to the skin of the host. Consequent irritation causes a swelling which envelops the insect except for a tiny opening where the tip of the abdomen is exposed. Through this opening the flea obtains air and extrudes eggs which drop to the ground or remain within the swelling. After oviposition the female remains to cause continued infection. Serious results may follow when chigoes penetrate in close proximity to one another.

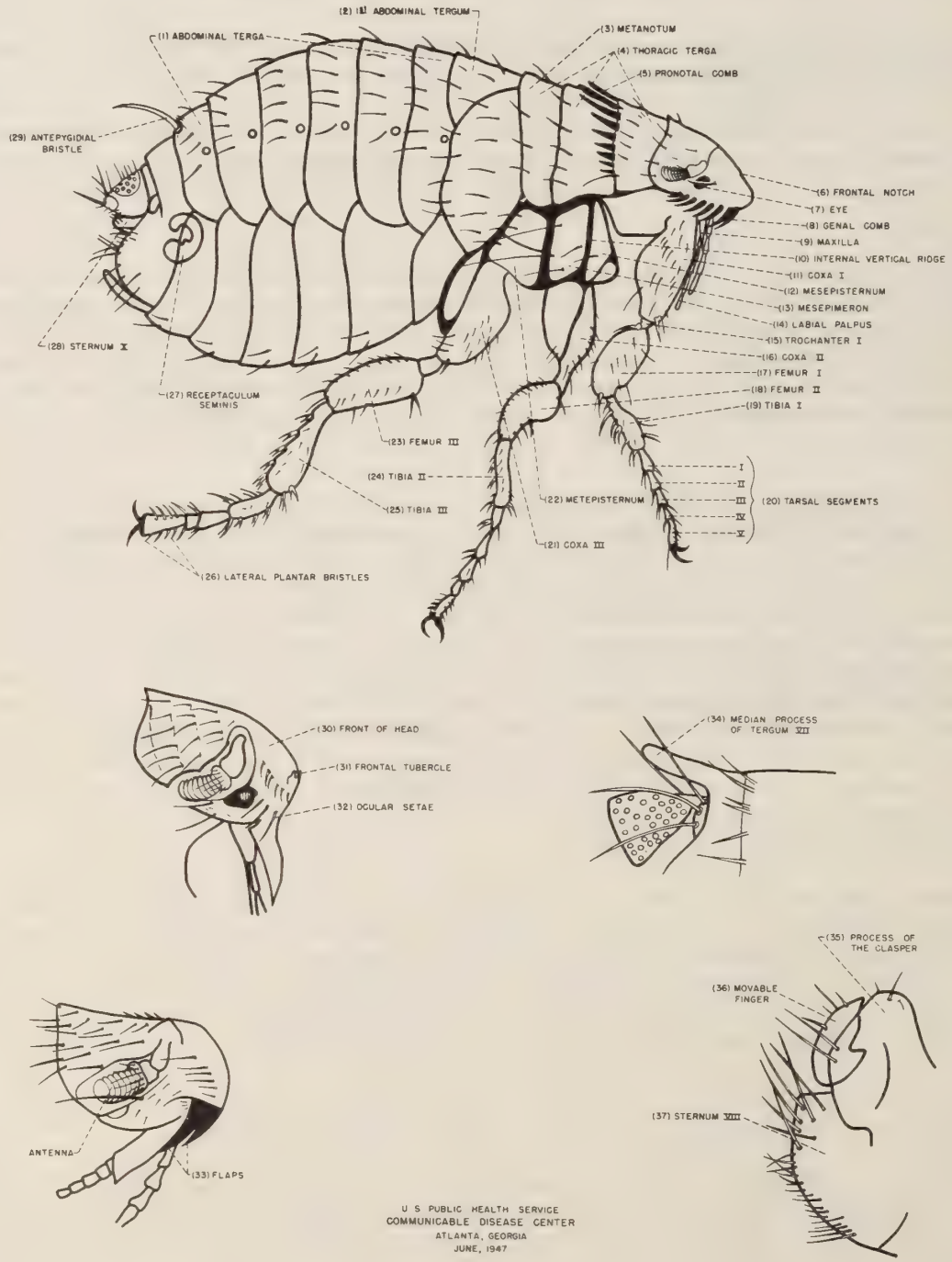
Rodent fleas breed in the nests and burrows of their hosts. The adult fleas are often present in great numbers on the hosts, but they also occur in and about the burrows.

Control-DDT and Chlordan: DDT is the poison of choice for destroying fleas. The powder, in 5% to 10% concentration, dusted along rat runways and into burrows and nesting areas, is being utilized on typhus control projects. The 5% powder has been found as effective as the 10%, but operators prefer the latter.

The sleeping places of pets are most heavily infested, but if pets have the run of the house, all rooms, especially the basement, may become infested.

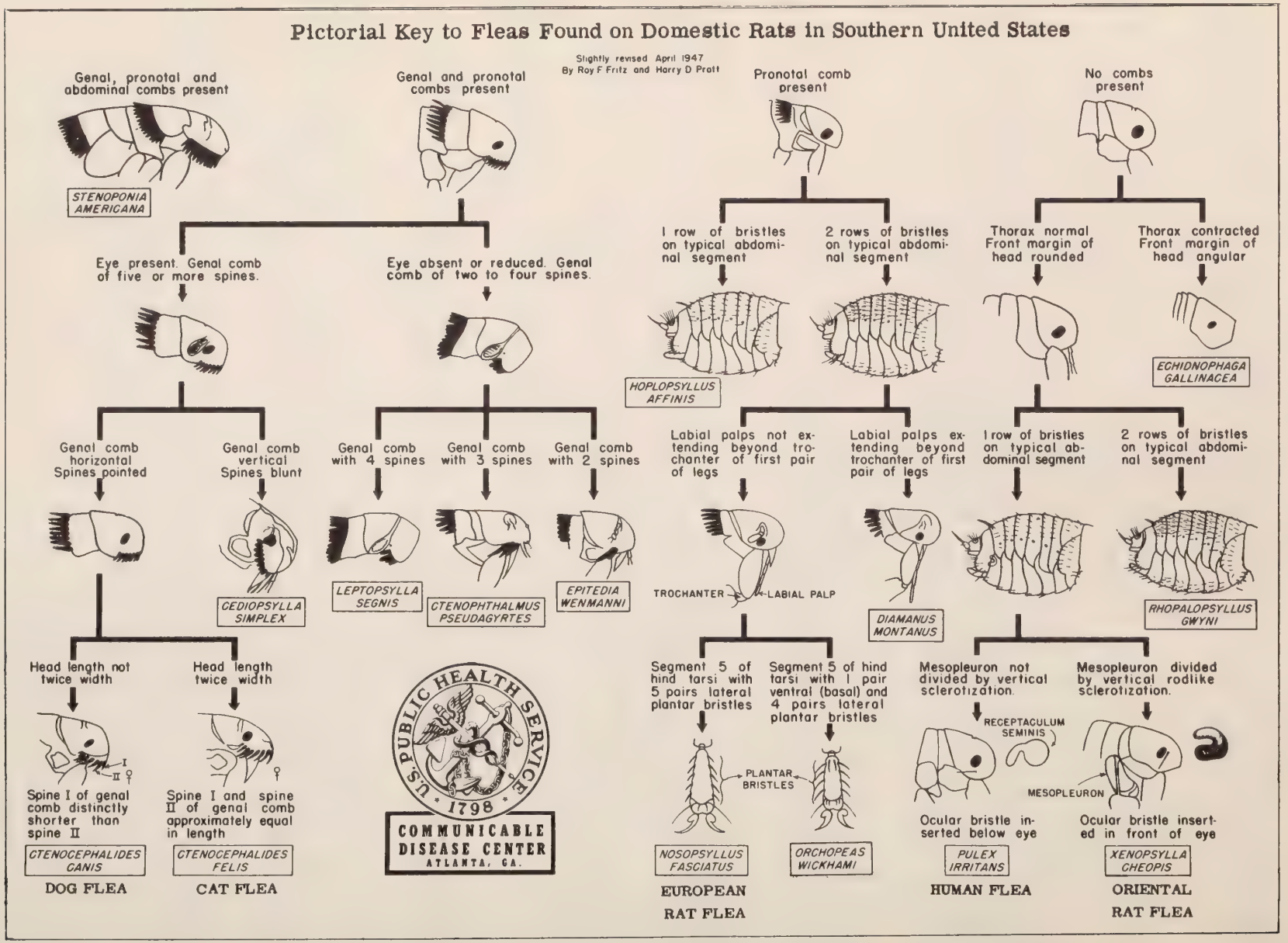
Fig. 6

Diagrammatic Anatomy of the Flea Genera of the United States



U S PUBLIC HEALTH SERVICE
COMMUNICABLE DISEASE CENTER
ATLANTA, GEORGIA
JUNE, 1947

Fig. 7


Pictorial Key to Fleas Found on Domestic Rats in Southern United States
Slightly revised April 1947
By Roy F Fritz and Harry D Pratt
Genal, pronotal and abdominal combs present
STENOPONIA AMERICANA
Genal and pronotal combs present
Pronotal comb present
No combs present
Eye present. Genal comb of five or more spines.
Eye absent or reduced. Genal comb of two to four spines.
1 row of bristles on typical abdominal segment
2 rows of bristles on typical abdominal segment
HOPLOPSYLLUS AFFINIS
Thorax normal Front margin of head rounded
Thorax contracted Front margin of head angular
ECHIDNOPHAGA GALLINACEA
Genal comb horizontal Spines pointed
Genal comb vertical Spines blunt
Genal comb with 4 spines
Genal comb with 3 spines
Genal comb with 2 spines
Labial palps not extending beyond trochanter of first pair of legs
Labial palps extending beyond trochanter of first pair of legs
1 row of bristles on typical abdominal segment
2 rows of bristles on typical abdominal segment
CEDIOPSYLLA SIMPLEX
LEPTOPSYLLA SEGNIS
CTENOPHTHALMUS PSEUDAGYRTES
EPITEDIA WENMANNI
TROCHANTER
LABIAL PALP
DIAMANUS MONTANUS
RHOPALOPSYLLUS GWYNI
Head length not twice width
Head length twice width
Segment 5 of hind tarsi with 5 pairs lateral plantar bristles
Segment 5 of hind tarsi with 1 pair ventral (basal) and 4 pairs lateral plantar bristles
Mesopleuron not divided by vertical sclerotization.
Mesopleuron divided by vertical rodlike sclerotization.
RECEPTACULUM SEMINIS
PLANTAR BRISTLES
MESOPLEURON
Spine I of genal comb distinctly shorter than spine II
Spine I and spine II of genal comb approximately equal in length
Ocular bristle inserted below eye
Ocular bristle inserted in front of eye
CTENOCEPHALIDES CANIS
CTENOCEPHALIDES FELIS
NOSOPSYLLUS FASCIATUS
ORCHOPEAS WICKHAMI
PULEX IRRITANS
XENOPSYLLA CHEOPIS
DOG FLEA
CAT FLEA
EUROPEAN RAT FLEA
HUMAN FLEA
ORIENTAL RAT FLEA
U.S. PUBLIC HEALTH SERVICE
1798
COMMUNICABLE DISEASE CENTER
ATLANTA, GA.

Dust the infested rooms thoroughly with 10-percent DDT powder and pay special attention to sleeping places of the pets or to places where they are accustomed to lie down. The powder can be dusted into cracks and crevices, in basements, and in other places where fleas may breed. The excess powder can be wiped up with a cloth or removed with a vacuum cleaner. If a board floor be dusted, the powder can be left in place for a day or two and then swept up. By sweeping across the boards, much of the DDT is forced into the cracks and will remain between the boards where flea larvae live. If left in place, the treatment may control fleas as long as 80 days after dusting. Flea-infested yards and leaves can be treated with the powder. A 10% Chlordan dust is recommended for use in controlling soil infestation of cat and dog fleas. A single application is usually effective. For the same purpose, a 2 1/2 percent DDT wettable powder spray or a 5 percent DDT spray either in a highly-refined kerosene solution or in an emulsion may be applied to floors, rugs, furniture, and in places where pets sleep. About 1 quart of a 5-percent DDT spray covers 250 sq. ft. of surface. If a kerosene-base spray be used, take precautions to avoid danger from fire. Aldrin and lindane are also effective against fleas.

Most dogs of average size may be dusted safely with about a tablespoon of 10 percent DDT powder. Often a line of dust along the middle of the back is sufficient to kill all the fleas and to prevent reinfestation for a week or more. DDT dust activates fleas before causing their death. The rapid crawling and biting of the fleas cause the dog to scratch and bite vigorously until the fleas are paralyzed.

Cats should not be treated with DDT dusts, because they lick themselves and may swallow enough DDT to make them sick. Treating the house and the cat's bed will probably be sufficient without having to treat the cat itself.

Many commercial flea powders contain some pyrethrum, rotenone, or other quick-killing poison in addition to DDT. When used alone, DDT is slow in action.

There is evidence that DDT is not very effective against cat fleas. Lindane and chlordan, besides pyrethrum, are safe for use on animals infested with DDT resistant cat fleas.

DDT dissolved in oil may be absorbed directly through the skin of animals with fatal results. Kerosene and other oils are poisonous to the skin. Several instances are already on record of valuable animals being killed as a result of their being sprayed with or dipped in DDT oil solutions. Never use DDT in oil solutions on animals.

Other Older Treatments: Creosote oil spray has been used for spraying basements, warehouses, outbuildings, dog kennels, and beneath houses. In rooms and on furniture infested with pet fleas, about 1 pound of flake naphthalene or powdered pyrethrum per 50 to 100 square feet may be scattered and left in place for at least 24 hours. This material may be swept from one room to another for treatment.

Cresol, Kerosene and Derris powder may be used in case of animals kept in quarters, and where DDT may not be used. Treatments of the individual animal with derris powder should be carried out systematically, usually every two weeks. Washing pets with 3% cresol solution or 10% emulsion of kerosene in soapy water is effective. This is not only effective in destroying adult fleas and eggs, but also larvae and pupae. Since the effectiveness of derris is largely dependent upon the amount of rotenone it contains, and much of the derris now on the market contains a comparatively high rotenone content, this material for use on cats may be safely diluted with talcum powder in the proportion of 1 part derris to about 2 of talcum, flour, or cornstarch. An ordinary salt shaker will be found useful in applying the powder as the hair is parted with one hand. This treatment should be repeated at intervals of 2 weeks where the animals have free run in order to prevent reinfestation of living quarters. Pyrethrum powder can be used instead of derris root.

Repellents. Effective flea repellents have recently been developed. They are: undecylenic acid, benzyl benzoate, n-butylacetanilide, n-propylacetanilide, hexyl mandalate. These are applied to clothes at the rate of 2 grams for each square foot of cloth and it remains effective for at least 10 days.

Prevention of Spread of Fleas. Transportation of fleas should be prevented as far as possible.

Household effects may harbor these pests in all stages, especially as immature forms in rugs and furniture. Fleas may be transported among mail sacks or other materials used by animals for beds. Persons carrying infested clothing or bedding may spread fleas. Motor trucks, railroad trains, airplanes, and ships must therefore be considered in combating fleas. DDT powder and spray are especially adaptable to the prevention of spread of fleas. Rat control on common carriers is a primary measure.

Control of Lice.

Human lice are the vectors of typhus fever, trench fever, relapsing fever, and plague in some circumstances. These insects belonging to the order Anoplura are blood suckers. The two genera in which we, in public health, are especially interested are Pediculus and Phthirius. To these genera belong 3 important species, Pediculus humanus capitis (head louse), Pediculus humanus corporis (body louse or cootie), and Phthirius pubis (crab louse). Each species of lice is parasitic on a particular type of animal host, and is usually not found in nature on any other host. For example, dog lice infest dogs almost exclusively, just like human lice infest humans and will draw blood from man almost exclusively.

Rat lice are also sucking lice, and may be vectors of disease among rodents and possibly between rats and humans. Lice commonly found on rats in the Southern states are: Polyplax spinulosa has world-wide distribution, is a common vector of typhus among rats, may carry typhus to humans but is of no importance in the latter role since it ordinarily does not feed on humans. Hoplopleura oenomydis, closely resembles H. acanthopus, is abundant in the south and its role in spreading typhus is not known. Hoplopleura hirsuta is occasionally found in rats. DDT appears to have little effect on rat lice. Biting lice (Order Mallophaga) are found on fowl and are probably of importance as vectors of encephalomyelitis among fowl. They are not known to bite man.

Habits and Development. Lice develop through 3 stages, the egg, the larva or the nymph, and the adult. This is called an incomplete metamorphosis (complete metamorphosis refers to the type of development associated with 4 states, namely, egg, larva, pupa, and adult, as in the mosquito.)

The egg of the body louse, is deposited on the hair of the body or head and also on the fibres of clothing. These eggs are attached to the hair by a cement-like substance excreted by the female. The head louse lays eggs in the head hair, the body louse in the hair of the chest and armpits (axilla) and on the fibres of rough clothes such as woolens, linens, and to a less extent on smooth materials such as silk, and the crab louse lays its eggs in the hairs of the pubis and groin. The eggs are ovoid, 1 millimeter in length, translucent when first deposited, and then become yellowish and opaque. They hatch in about 8 days at 86° F. to 90° F., which is the usual temperature of clothing on the body. At lower temperatures the incubation period may be prolonged to several weeks. The eggs of the above mentioned 3 species are very similar in appearance.

The louse larva resembles the adult but is much smaller. It is white in color and will die if it does not obtain a blood meal within 24 hours after hatching. It moults 3 times at 3 days interval and gradually gets larger. After the 3rd moult it emerges as a sexually mature adult. The second and third larval stages, are called the nymphal stages. If the clothes be worn continuously, the louse will develop into an adult in 17 or 18 days from the time the egg is deposited. But if the clothing be taken off every night and its temperature thereby lowered the period of development is prolonged. The larvae of the crab lice are very similar to those of the body and head lice except that the latter two migrate from place to place in their environment while the former remains very stationary.

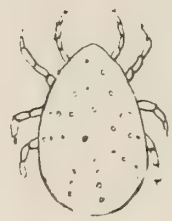
The adult louse begins to lay eggs within a day after its emergence from the larval stage. It lays 5 to 10 eggs per day and under suitable conditions of food and temperature, it will continue to lay for 30 days. Besides laying eggs in the body hairs, the body louse seeks out that part of the clothing which is in close contact with the body to lay its eggs. Thus one would expect to find eggs in the seams of the clothes around the collar, the waist, and the crotch or in places where the clothes are in double layers, and in these places one would also expect to find the adult. The adults are voracious feeders. They take several blood meals daily. The body louse likes to cling to the clothes while feeding, therefore it feeds more frequently while the host is quite or asleep. The bites of the louse are usually irritating and itchy and therefore cause a good deal of scratching and rubbing. When it bites it injects its salivary fluid into the wound which has the property of preventing the clotting of blood and assures it a free flow of food. It also has the habit of defecating while

Fig. 8

Various Insects Important in Hygiene

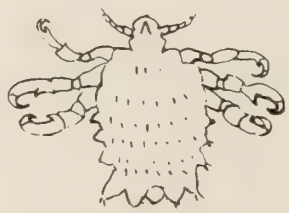
Cockroach
(Periplaneta americana)

Body Louse
(Pediculus humanus corporus)



Soft Tick
(Family Argasidae)

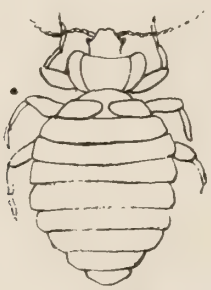
Mite
(Sarcoptes scabiei)



Crab Louse
(Phthirus pubis)

Hard Tick
(Family Ixodidae)

American Chigger or Redbug
(Tromicula irritans)



Bed Bug
(Cimex lectularus)

Midge or sandfly
(Phlebotomus papatasi)

it feeds. It is because of these two habits that it is able to transmit pathogens which it carries in its body. The germs may be injected into the human with the salivary fluid, or may be rubbed into the wound from the feces when the irritation causes the person to scratch and rub. The scratching may also cause the louse to be crushed on the site of the wound and thus infect the person from body fluids of the louse. The crab louse which is usually found in the pubic region may also be found on other parts. With its powerful claws it grasps 2 approximating hairs and remains fixed in its position, otherwise its habits are similar to the body and head lice. Because of the habits of the body louse it is most easily transmitted from person to person and it is therefore the important vector of louse borne diseases.

Transmission. Lice are transmitted from person to person by direct and indirect contact especially under crowded conditions. The insects may migrate by day and by night especially during sleep. They may be shaken from bed to bed from blankets. In schools, moving picture theatres and camps, the transmission may take place. Exchanging blankets and clothes is another way. The crab louse is usually transmitted by sexual contact when loose hairs of one get tangled into the pubic hairs of another person. In crowded camps and hospitals they may spread from person to person by the transfer of hairs to which eggs are attached. Lice are sensitive to temperatures above normal human temperature. At 100° F. they migrate from the feverish person to seek persons with normal temperatures. When a person dies, his lice parasites will migrate to find a living host. The head and body lice will die of starvation if separated from the human host. They may live without a blood meal for a week at 68° F., for as long a 10 days at 40° F., for about 2 days at 80°F., and for about 12 hours at 104° F. The crab louse will die in about 2 days if separated from the human host.

Control Measures. DDT. DDT is effectively used against all species of human-infesting lice and is easily applied, but a knowledge of the different species of lice is essential for effective use of DDT.

Head Lice. A 10 percent DDT dust is effective against head lice. A teaspoonful of 10 percent dust should be rubbed thoroughly into the hair. Since DDT does not kill the eggs or nits, a second treatment should be made in order to kill the larvae that hatch from the remaining eggs. The residual toxic effect of DDT, the duration of which varies, keeps destroying the adults and larvae so that new eggs are not laid. The second application of DDT is made in 8 to 10 days since it takes about that long for eggs to hatch when exposed to normal body heat. In this way DDT effectively disinfests individuals even though it does not directly destroy the eggs. The use of this chemical is the cheapest, most easily and most rapidly applied, and the most economical for mass application in the control of all types of lice.

Liquid solutions of DDT for head lice are also available, but the manufacturer's directions should be followed carefully, since DDT in solution can be dangerous.

Body Lice. Since body lice are usually found in clothing and not on the body itself, clothing should be treated, especially the underwear where lice are most likely to be found.

Sift 10 percent DDT powder over the entire inner surface of the underwear and take special care to rub it into the seams. The inside of shirts, trousers, hats, and other articles of clothing should be treated at the same time. About 1 ounce, (2 heaping tablespoonfuls), of the powder per treatment will remain effective for periods of three weeks or longer if the clothing be not washed. Clothing treated in this way will kill lice even after being washed once in warm soapy water.

Great care should be taken to avoid reinfestation from discarded clothing or bath towels. Bedding can also be treated by dusting between sheets.

During epidemic periods, dusting the clothes with hand or power dusters is the method of control when quick action is required. Such dusting does not require undressing, but can be accomplished by inserting the long nozzle of the duster up the sleeves, down the neck, up trouser legs, around the belt, etc. allowing several strokes of the duster in each position, not forgetting also to dust the hair.

Allethrin as a 0.1% powder may be used as an alternate for lindane or pyrethrum in control of

DDT-resistant human body lice.

Crab lice. Crab lice infestations can be controlled easily by dusting the affected parts lightly with a 10 percent DDT dust. The pubic region and armpits are most commonly infested. In a very hairy person the entire body should be dusted lightly.

A second application should follow 8 to 10 days after the first to kill any young lice which may have hatched during this time.

Other Control Measures. Heat: In the absence of DDT, heat may be used for destroying eggs, larvae, and adults. Moist or dry heat may be used effectively. Steam is the most practical since it does not shrink wool and can easily be produced. Boiling water will shrink wool. The wet methods cause wrinkling and unsightly appearance in outer wearing apparel. Articles made of leather, felt, or webbing are damaged by steam. Dry heat does not cause shrinkage or wrinkling, but tends to damage woolen fabric. Dry heat will not injure leather. The ordinary pressure sterlizer is an efficient method for destroying all forms of lice; 20 to 30 minutes in such a sterilizer is sufficient to accomplish destruction of lice.

Clothing and blankets may be disinfested in ovens, boxes, cans, and the like by subjecting them to high enough temperatures by dry heat. Small rooms may be heated to 160 degrees F., and clothing loosely placed in here will become thoroughly disinfested in 30 minutes. Clothes, well ironed with hot irons, will become disinfested.

Cotton, linen, or silk may be disinfested by boiling for 1 minute, or subjected to hot water at 135 degrees F. for 5 minutes or more. In order to disinfect as well as disinfest clothing it should be subjected to a temperature of 160 degrees F. for a period of 15 to 30 minutes.

Cresol. 5% cresol solution is efficient disinfestant for shoes, belts, felt articles and clothing. Clothes can be soaked for 30 minutes in the solution then wrung out and dried. 3% cresol solution at 100 degrees F. will disinfest clothing and other articles if immersed for 30 minutes.

Storage. By depriving lice of food, infested clothing or other articles may be stored for 30 days in cold weather and 3 weeks in warm to destroy them by starvation.

It must be remembered that DDT has displaced the many chemical and elaborate heat methods for destroying lice. These latter methods may still be useful in institutions such as hospitals where quick and effective destruction of eggs, larvae, and adults are required. In out of the way places where DDT is not immediately available 10% acetic acid (vinegar) or hot soapy water containing 25% kerosene will loosen and wash out eggs from the hair.

Cockroach Control.

Types of Roaches. Cockroaches are of numerous species, nearly a thousand being described. There are four species of roaches that may become abundant or persistent annoyers. The largest of all species is the American roach (Periplaneta americana). It is light brown, from 1 1/2 to 2 inches long when fully grown, and all adults have long powerful, reddish-brown wings with which they fly readily. The oriental roach (Blatta orientalis) is often called the "black beetle," because it is entirely black or deep brownish black; it is about 1 1/4 inches long when well grown, rather sluggish in habits and thrives best in very damp places. The females have partially developed wings and cannot fly. The German roach (Blattella germanica) is never more than 5/8 of an inch long when well grown and is one of our most common roaches in buildings. Its light brown color is offset on the back between the head and the wings with two dark parallel blackish stripes. Its wings are uniformly light brown and fully developed. The brown banded roach (Supella supellectilium) is a species quite like the German roach, but thrives best in more tropical situations, particularly in the southern half of the United States and Central America. The females are seldom longer than 3/8 of an inch when well grown, but the males become about 1/2 inch long. The young tropical roaches are very easily distinguished by two bright yellow or whitish transverse bands on the abdomen.

Development. Roaches are very slow in development. The fully grown female of the American

roach at room temperature has been known to live 441 days and to produce 58 capsules averaging 14 eggs each. The young require from about 30 to 60 days to mature sufficiently to leave the egg, and require an additional 285 to 971 days to arrive at adult growth. The German roach thrives under warmer conditions and has been known to complete its life cycle from egg to adult in 90 days. But female adults have lived 260 days, laid 6 capsules averaging in content 30 eggs each which hatched in 28 days at 76 degrees F., the young requiring another 103 days at the same temperature to reach the adult stage. The growth of the roaches is influenced greatly by temperature, humidity and the food available, and their development, therefore, is subject to great variations in length of time that eggs, young and adults are apt to be present at all seasons of the year in and about buildings inhabitated by the more troublesome species of roaches.

Habits. Roaches may become troublesome in any establishment where foods are stored, cooked or served. They can be very destructive to library books by eating the starches and glues from the bindings and they may gnaw holes in clothing. They contaminate food by running over it. This places them in the class of disease carriers. It has been shown that disease organisms may be carried on the legs of roaches and that the same organisms can be found in their feces passing through the alimentary canal uninjured. Barber, experimenting with the American roach, fed cholera dejections to the roaches and found that a single insect would ingest as much as 0.2 cc. In eight cases, cholera vibrios were recovered from the insects' feces, and in one case as long as 79 hours after feeding. After the vibrios were discharged by the roach on such moist material as fresh beef, lettuce, etc., they remained mobile for at least 16 hours and no loss of virulence was observed when the vibrios remained in the insect's intestine as long as 29 hours. Barber also found that the roaches disgorge portions of their meal at intervals after feeding and such disgorged material contained cholera vibrios. Possibly, poliomyelitis may be spread by roaches.

The offensive, sickening or fetid odor associated with cockroaches is due largely to an oily liquid secreted by scent glands. This oil leaves the characteristic roachy odor wherever the insects are abundant. Food is ruined by it and the dishes over which the roaches run may seem apparently clean, yet give off the odor when warmed unless thoroughly washed in hot water and soap. The pellets of excrement as well as the ink-like liquid emitted by roaches from their mouths contribute to the development of the nauseating odor.

Because roaches are cosmopolitan, some one or more species are to be found almost everywhere. They sometimes fly into buildings from moored vessels. They have been observed to migrate in droves from place to place and many undoubtedly crawl in through door and window openings. They remain rather quietly in sheltered, darkened spots during the day time and they do their foraging for food at night. They usually hide near sinks, drainboards, behind wall cabinets and radiators, under loose door and window trim. If disturbed, they run rapidly for concealment and disappear through cracks, holes in walls, down along water and steam pipes and similar openings. They may thus congregate beneath floorings, in wall space, sometimes forming masses so dense that they obscure the surface upon which they rest and over which they move like herds when disturbed. Knowledge of where they conceal themselves is the key to control.

The method of laying eggs and nocturnal habits of roaches are important factors to be considered in control operations. The eggs are found, not singly or in unprotected groups, but are encased in chitinous, more or less rigid capsules located in the body of the roach before being deposited. The female deposits the capsules and emits a gummy solution which causes them to adhere to the object upon which they are deposited. An exception to the habit of most roaches in gluing their egg capsules to surfaces is that of the German roach, which carries the capsule partially extruded from the body until the eggs hatch or are about to hatch, when the capsule is dropped loosely on any surface.

Control. Roach elimination is not difficult if the sources of infestation can be controlled. In loosely constructed buildings or where a mild climate permits roaches to develop out of doors, buildings are constantly being reinfested from outside by crawling and flying roaches. No control will keep a building free from roaches continuously if sources of reinfestation exist.

Chlordan in 2 to 2.5% emulsion or oil solution is recommended for spot spraying or painting for roach control in homes. Such treatment should be confined to limited harborage areas such as

behind baseboards and in cracks and crevices, and around openings through which roaches may gain entrance from outdoors. Overall applications of chlordan should not be made in homes.

Dieldrin is also effective in control of roaches as 0.5% solution or as a 1.0% dust.

Other older Types of Roach Insecticides. Pyrethrum powder is used in the same manner as sodium fluoride and is not injurious to man or pets, but it loses its effectiveness readily if not repeatedly applied.

Borax is applied in the same manner as the above 2 powders. It is not poisonous and not as effective as sodium fluoride or pyrethrum. It is usually made up as a mixture of 3 parts borax to 1 part flour, or 1 part sodium borate to 1 part pyrethrum powder and 5 parts flour.

Sodium fluoride, although effectively poisonous to roaches is also very poisonous to man and should not be used when safer methods can be substituted. It becomes ineffective for roaches when it gets damp and clumped. It is applied by duster or sprinkled along the back of shelving and drainboards and in the hiding places of roaches at intervals of one or two weeks until the roaches disappear. The powder is applied in the evening and should not be cleaned up for 2 to 3 days.

There is no reason for using phosphorus paste anymore since it is extremely poisonous to man and since the new insecticides are better.

Fumigation. This method is not ordinarily used any more because of the discovery of new insecticides. There is, however, a place for its use, in ships, granaries and other places where the rooms are tight and there is a need for the quick elimination of the pest. The gas can be used in granaries because it will not poison the grain materials.

Fumigation must be carried on under the direction of personnel trained and professionally experienced in such work. Whether the use of fumigation is warranted will depend on circumstances. In more loosely constructed buildings the fumigant usually escapes so fast, that eggs of roaches, protected in the egg capsules, are not always killed and a second fumigation about 3 or 4 weeks later may be necessary. The dosage depends on the construction of the building. A 12-hour fumigation, using 12 ounces of sodium cyanide for each 1000 cubic feet is recommended. Caution: Hydrocyanic acid gas is a deadly poison and should be used only by experienced operators exercising all safety requirements. Most camps can be fumigated safely with hydrocyanic acid gas provided the structure is detached and 15 to 20 feet distant from other buildings. The structure must be completely vacated and guarded during the 6 to 8 hours of fumigation and until thoroughly ventilated.

Bedbug Control.

The mature, well grown bedbug is a wingless, brown insect between one-fourth and three eights of an inch long. Two species are important. Cimex lectularius and Cimex hemiptera (rotundatus). The former is the common bedbug or northern latitudes, the latter the bedbug of the tropics. Both have the same habits and life history.

It is not definitely known that the bedbug transmits any disease, but it has been accused of carrying kala-azar, plague, anthrax, relapsing fever and typhus. It is an efficient experimental host of Trypanosoma cruzi and Leptospira icterohemorrhagica.

Habits and Characteristics. When unfed the bedbug is very flat. When engorged with blood, the body loses its paper-thin appearance and becomes more elongated and swollen, and the blood within its body gives it a more reddish appearance. The food of bedbugs is the blood of warm-blooded animals, principally man. Both males and females suck blood. Their mouth parts are so constructed as to form a sharp beak, or proboscis, which can be thrust into the skin through which blood of its victim can be drawn. It requires a continuous feeding of 3 to 5 minutes for a well grown bedbug to become engorged with blood. Once filled to capacity, the bug withdraws its beak and quickly crawls to its hiding place where it remains for several days digesting its meals, seemingly indifferent to its host. When hunger finally reasserts itself, the bedbug comes out of hiding and seeks out its host for another meal. The bedbug can live, however, for as long as 9 months or more without food.

They are normally nocturnal in habit. When darkness arrives, they emerge from their daytime hiding places and seek to feed upon their host. Sometimes, when very hungry, they will feed in subdued light during the daytime. Their normally nocturnal habit is modified when they infest furniture in rest rooms, in stores, theatre seats, desks in offices and similar situations that are not frequented by man throughout the night. In such places they often bite persons during the day. A common hiding place is behind wall paper.

Bedbugs are distributed in many ways. They crawl freely to their victims from their hiding places, even dropping upon them from the ceiling. They are believed to be actively migratory at times, travelling on their own power from room to room, besides being carried in bed clothing. There appears to be evidence that they migrate from house to house. Probably clothing, baggage, secondhand furniture, laundry done in private infested homes, and visitors are the chief means of spread.

Development. The mature female bedbug, under favorable conditions, is said to live from 6 to 8 months, and has been known to lay as many as 541 eggs, although 200 eggs is probably a fair average. When temperature and food conditions are favorable, eggs are laid at an average rate of 3 to 4 a day. No eggs are laid at temperatures lower than 50 degrees F. and very few between 50 and 60 degrees F., while maximum oviposition occurs only above 70 degrees F. and when the female has ample opportunity to feed. Starved females soon stop laying eggs. At temperatures above 70 degrees F. the eggs hatch in 6 to 17 days. At lower temperatures they may not hatch for 28 days. The eggs are white, about one thirty-second of an inch long, are oval in shape, and at first are coated with a mucilaginous substance which forthwith dries, sticking them to the object upon which they are deposited.

The newly hatched translucent and nearly colorless young bedbug feeds at the first opportunity. During growth the young bedbug closely resembles the parent insect. It molts, or sheds its skin 5 times in reaching maturity. It must feed after each molt in order to grow and molt again. The cast skins are white and fluffy and often accumulate in piles in cracks of bedsteads, in spaces about window and door frames, behind wall pictures or any other place where the bedbugs hide during the daytime. Full nymphal growth requires from 4 to 6 weeks during warm summer weather or in houses continuously heated. There may be three or four generations a year or even more in warm climates. Generations overlap and all stages may be present at all seasons of the year.

Bedbugs are sensitive to temperature and are apparently more numerous in cold than in hot climates. It is remarkable how very few bedbugs are found in Mesopotamia. A temperature of 96 degrees F. to 100 degrees F., with a fairly high degree of humidity, is said to kill large numbers. Adult bedbugs can resist temperatures below freezing for some time. Eggs and larva are not quite so hardy.

Control. In combating bedbugs, first find where they are hiding such as in seams of mattresses, cracks and crevices of the bedstead, in the hollow interior of the frame of metal cots, behind baseboards, window and door casings, pictures, moldings, loosened wallpaper, in cracks in plaster or partitions of composition board. They do not crawl far into wall spaces for hiding. Habitual hiding places are usually made evident by the disfiguring spots that stain surfaces upon which the bugs rest. Frequent inspection of beds by an experienced sanitarian will detect the presence of a few bugs and permit application of control and prevent infestation from becoming serious.

DDT is an effective weapon against bedbugs and is far superior to the pyrethrum sprays formerly used in controlling these pests. When a 5 percent DDT spray is properly applied to mattresses and bedsteads, a single treatment will "bugproof" them for six months or longer. A smaller hand sprayer can be used to force the DDT solution into each crack and joint of the bed and into the springs. Spray all surfaces - top, bottom, and sides - until they have a misty wet appearance. Be sure to get the spray into the seams and folds where the bedbugs hide. About 1/2 cup of 5 percent spray should be sufficient for each bed. DDT is somewhat slow in its action against bedbugs, taking about 48 hours after exposure to kill them. In heavy infestations, spray the walls around the bed, cracks along the baseboards, surfaces behind loose wall-paper, and other small spaces in the bedrooms where the bugs may hide during the day.

Chlordan. This weapon against the bedbug is also very effective and is used in the same manner as DDT. Like DDT, its residual toxicity remains effective for a prolonged period.

Other methods. Because of the above effective bedbug destroyers there is no longer need for use of other sprays such as pyrethrum or kerosene. The method of killing these bugs by super-heating rooms to 120° F. for 10 to 12 hours is also going into past history.

Fumigation. Ordinarily this method need not be used for bedbug control. But for quick control in emergency circumstances, fumigation may be used as described under "roach control".

Tick Control*

Ticks may be divided into two families - Ixodidae, Hard ticks, and Argasidae, soft ticks. Amongst the ticks, the Ixodidae can easily be recognized by their terminal projecting mouth parts, and by the presence of a dorsal shield which is small in the female and in the male covers practically the whole body. The mouth parts of the Argasidae are not terminal and there is no dorsal shield in either sex. The mature ticks bear 4 pairs of legs and the larvae have 3 pairs of legs. The food of ticks consists entirely of blood and lymph and both males and females are blood suckers in all stages of their development.

The tick, Dermacentor andersoni (wood tick) spreads rocky mountain spotted fever in western United States, while D. variabilis (dog tick) spreads this disease in eastern United States. The tick also is the vector of louping ill in sheep. "Q" fever is spread by a number of ticks, hard and soft, i.e. Dermacentor andersoni, Amblyomma americanum, Ornithodorus moubata and O. hermsi in the United States. Tularemia may be spread by hard and soft ticks, i.e. D. andersoni; D. variabilis, D. occidentalis, A. americanum, O. turicata, O. parkseri, and the rabbit tick Haemaphysalis leporis-polustris. Relapsing fever is spread by the soft tick, genus Ornithodorus. Lymphocytic choriomeningitis may possibly be spread by a tick. The salivary secretions of some species of ticks produce shock and paralysis which, in case of children, may end fatally at times. Texas tick fever (Piroplasmosis) among cattle is spread by the tick Margaropus annulatus (known also as Boophilus annulatus).

Life History. This varies with different ticks. That of the genus Dermacentor may be taken as representative of the group. After the adults have succeeded in reaching a suitable host, they engorge, then mate and drop from their host to the ground. The males die soon. The females deposit their eggs in some protected place away from the host and then also die. From 2000 to 8000 eggs are deposited in the course of a month. The number of eggs varies from 1 or 2 hundred in the argasine to 20,000 in certain of the ixodine. After a period of development of a month or more, a small 6-legged larva emerges. This crawls up a blade of grass and waits until it can attach itself to some passing animal. It then engorges and within a few days drops to the ground. Here it undergoes further development for several weeks, finally moulting and becoming an 8-legged nymph. This in turn climbs up a blade of grass or a twig and awaits another passing animal. It engorges itself again and drops to the ground. After several weeks of development, it moults and becomes an adult. It then finds its third host. A female tick may ingest 100 times its weight in blood. The length of the life cycle varies with weather conditions. In case of Dermacentor andersoni it is over 2 years, passing the first winter as an unfed nymph and second winter as an unfed adult. In other species the cycle is completed in a season. Winter may be passed in the egg stage. Ticks have an extraordinary capacity to withstand starvation. Larvae have survived 7 to 8 months and adults 3 to 5 years without food. Among the argasine, the adults engorge and mate several times on different hosts. Among some ixodine, the larva, nymph and adult may develop on one host. In some species the males do not bite. Ticks do not usually live upon, but live around the animals which they parasitize and therefore may be found in such places as rodent burrows.

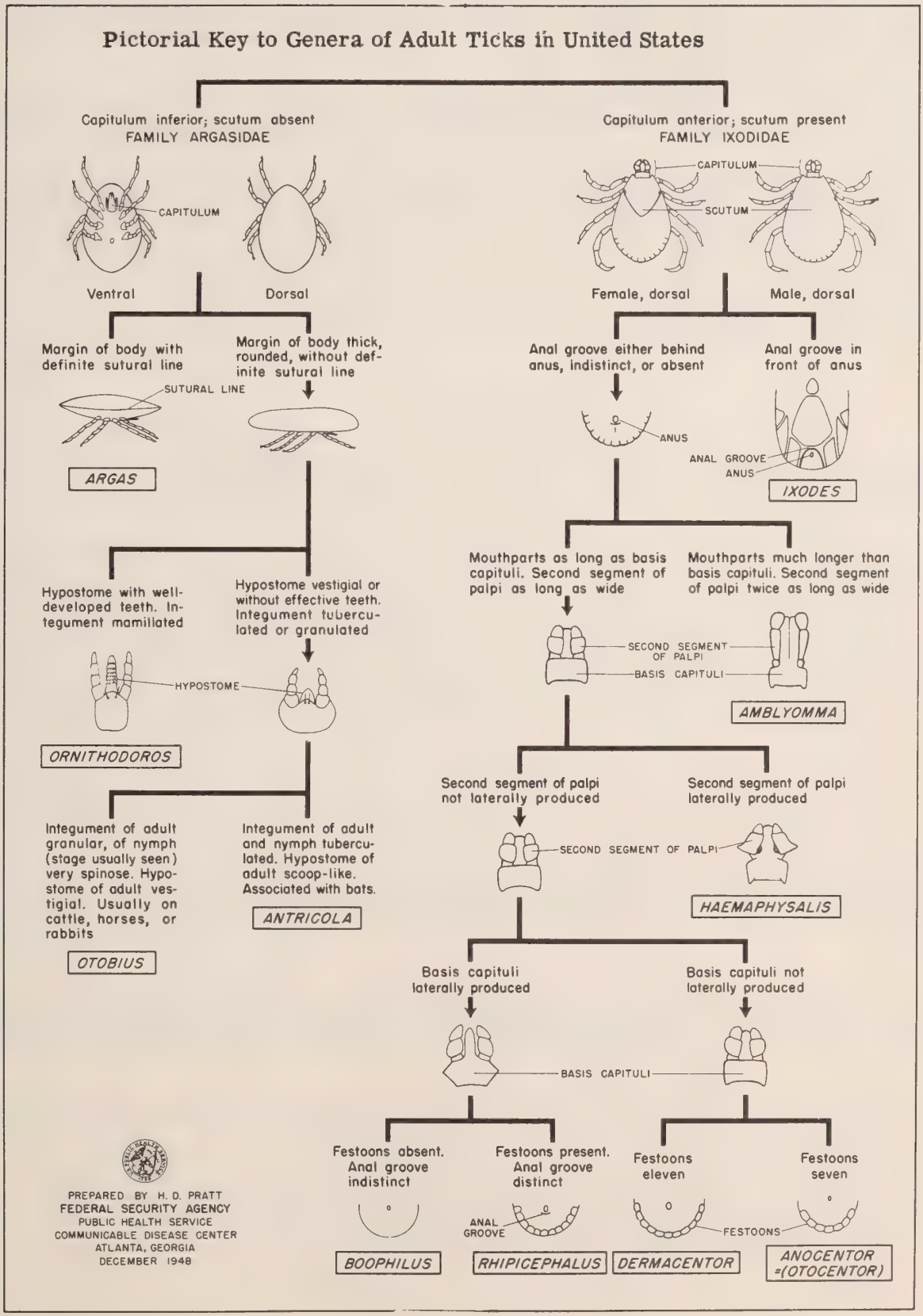
The soft ticks have similar feeding habits to that of the bedbug. They hide during the day and sally forth during the night. Some soft ticks like O. moubata live in human abodes.

Control. One does not usually feel when a tick is biting. A person is always completely surprised when he finds a tick attached. When force is used in an attempt to remove the attached tick, one of two things happen - either the surrounding skin is unnecessarily torn or, as is most probable, the body of the tick comes away, leaving the mouth parts buried in the skin. This sets up a severe irritation and may lead to infection. The following procedure is advocated for removal:

A small brush should be dipped in turpentine, benzine, gasoline or kerosene and applied

*Dr. McKiel, Chief of the Zoonoses Laboratory of the Laboratory of Hygiene and National Health and Welfare, Canada, found that the major factor in tick infestation was allowing land to remain fallow. The fallow ground is conducive to weeds, weeds to mice, and mice to ticks. An obvious method of control is to till the ground. It was found that the reduced intensiveness of ticks resulting from cultivation could be further reduced by also treating the area with a combination of herbicide and DDT.

Fig. 9


Pictorial Key to Genera of Adult Ticks in United States
Capitulum inferior; scutum absent
FAMILY ARGASIDAE
CAPITULUM
Ventral
Dorsal
Margin of body with definite sutural line
SUTURAL LINE
ARGAS
Margin of body thick, rounded, without definite sutural line
Hypostome with well-developed teeth. Integument mamillated
HYPOSTOME
ORNITHODOROS
Hypostome vestigial or without effective teeth. Integument tuberculated or granulated
Integument of adult granular, of nymph (stage usually seen) very spinose. Hypostome of adult vestigial. Usually on cattle, horses, or rabbits
OTOBIUS
Integument of adult and nymph tuberculated. Hypostome of adult scoop-like. Associated with bats.
ANTRICOLA
Capitulum anterior; scutum present
FAMILY IXODIDAE
CAPITULUM
SCUTUM
Female, dorsal
Male, dorsal
Anal groove either behind anus, indistinct, or absent
ANUS
Anal groove in front of anus
ANAL GROOVE
ANUS
IXODES
Mouthparts as long as basis capituli. Second segment of palpi as long as wide
Mouthparts much longer than basis capituli. Second segment of palpi twice as long as wide
SECOND SEGMENT OF PALPI
BASIS CAPITULI
AMBLYOMMA
Second segment of palpi not laterally produced
Second segment of palpi laterally produced
SECOND SEGMENT OF PALPI
HAEMAPHYSALIS
Basis capituli laterally produced
Basis capituli not laterally produced
BASIS CAPITULI
Festoons absent. Anal groove indistinct
Festoons present. Anal groove distinct
ANAL GROOVE
Festoons eleven
Festoons seven
FESTOONS
BOOPHILUS
RHIPICEPHALUS
DERMACENTOR
ANOCENTOR =(OTOCENTOR)
PREPARED BY H. D. PRATT
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
COMMUNICABLE DISEASE CENTER
ATLANTA, GEORGIA
DECEMBER 1948

between the skin and the undersurface of the tick. After a few minutes the tick will let go its hold, being killed by the application, and may be swept from the skin with the brush. If they be covered with oil or vasoline, thus closing their breathing pores situated behind the fourth pair of legs, they may be induced to release their hold. To remove the part that remains in the skin after the tick has been forcibly removed, it may be necessary to apply a local anesthetic and do the extraction with a needle forceps. A tick may also loosen its hold on applying a lighted cigarette in its immediate vicinity (the so-called "hot foot").

Tick bites are best treated by bathing the bitten part in very hot water and applying a strong solution of sodium bicarbonate. If itchiness persists a mentholated salve may be applied.

The control of ticks over a wide area has not been very encouraging. Clearing away brush and burning-over the tick infested area together with rodent control have been traditionally used without exciting results. Recently some evidence has come up to indicate that systematic mowing of pastures will reduce the tick population effectively. This is probably due to the fact that the free-living stages of the tick prefer shady places and are destroyed by sunshine. Keeping ticks off cattle has usually been accomplished by dipping the animals. Dips containing arsenic, rotenone, nicotine coal-tar creosote, cresol, and sulphur has been widely used. The composition of a dipping fluid often used is:

Sodium carbonate	24 pounds
Arsenic trioxide	8 "
Pine tar	1 to 2 gallons
Water, to make up . . .	500 gallons

Dipping is usually done at a 2 week or longer interval, depending upon the circumstances. If dipping be not feasible, then liberal application of the fluid to the animal by brush may be used.

Although recent studies have shown that DDT and probably other chlorinated hydrocarbons accumulate in the fatty tissues of animals and therefore should not be used on such animals as are used for human food, especially whose milk is used for human consumption, it has been shown, nevertheless, that diluted chlordan dips at concentrations of 0.75 percent gave nearly complete control of all stages of ticks on goats and cattle. The U. S. Department of Agriculture at present recommends water emulsion or wettable powder sprays or washes of 0.5% toxaphene or a combination of 0.5% DDT and 0.025% lindane applied to all parts of animal including ears. This procedure will eliminate infestation and will give protection against attack for 2 or more weeks. Protection was obtained for 80 days by dipping cattle in a combination of DDT and rotenone.

Dogs may be treated with derris powder containing at least 2% rotenone or 10% DDT dust. Kennels, poultry houses, dwellings and other infested places may be treated with 10% DDT dust.

Recent experiments have shown that spraying infested land with DDT, dieldrin, toxaphene, chlordan or BHC will give about 5 weeks of control when sprayed at the rate of 5 lbs. per acre in an emulsion or oil solution. DDT and dieldrin were the most effective, the others were somewhat less effective.

Effective tick repellents are the new compounds, namely, N-butylacetanilide, hexly mandelate, indalone, N-propylacetanilide, and undecylenic acid. When applied to clothing at the rate of 2 grams of repellent per square foot of cloth, or approximately 5% of the dry weight, the repellent effect remains for 10 or more days.

In 1926 parasitized nymphal ticks were introduced into Montana as a control measure but their usefulness is still undetermined.

The avoidance of tick bites is urged by keeping out of known tick infested areas during spring and early summer; or by wearing suitable clothing, such as high boots, leggings or puttees. The early removal of ticks minimizes the danger of infection.

Control of Mites

Chiggers, or red bugs, or harvest mites (class-Arachnida, Genus-Trombicula), as they are variously called, are the larvae of a large scarlet soil-inhabiting mite. The chiggers found in the

United States are not known to carry any disease, although other mites do, nevertheless, they do produce extreme annoyance to man by their bites. The intense itching caused by these pests often interferes with sleep and the poison injected may cause fever and loss of appetite. Infection is often introduced as a result of scratching. This may produce troublesome local sores, and boils sometimes result. The annoyance caused by chiggers often has a marked effect on the activities and efficiency of individuals. Men not accustomed to chigger attacks usually suffer most, though some never seem to acquire any degree of tolerance. The chicken mite, Dermanyssus gallinae, has been found naturally infected with western equine encephalomyelitis virus and St. Louis encephalitis virus. The larval form of the mite Trombicula akamushi is the vector of tsutsugamushi fever or scrub typus, the reservoir of which is a variety of rodents. It is possible that the rat mite may be a minor vector of endemic typhus and plague. In the southern part of the United States, the following mites are relatively abundant: Liponyssus bacoti, the tropical rat mite which attacks humans during rat-poisoning campaigns when there are not enough of rats to feed on. Its bite is malicious and it is suspected of being a vector of typhus. Laelaps nuttali (formerly called L. hawaiiensis), a small dirty yellow mite, will bite humans where it is abundant, and has been incriminated as a vector of typhus. Echinolaelaps echidninus, the common rat mite, is not known to bite man or to transmit typhus. Allodermanyssus sanguineus, commonly found on mice, has recently been shown to be a vector or rickettsialpox. There is a possibility that it might be a vector of lymphocytic choriomeningitis.

Distribution. In general, chiggers are more troublesome throughout the Southern States. They are, however, rather abundant in eastern Kansas, in Missouri, the southern portions of Illinois, Indiana, Ohio, Virginia, and southern Maryland. They are present locally in some more northern states, such as Iowa, southern Minnesota, and Wisconsin, and also in Pennsylvania. Scattered occurrences are reported northward along the east coast to Cape Cod, Massachusetts. They are not found in the western part of the United States, although some are present along streams in central western Texas.

There is considerable local variation in chigger abundance. They prefer bottom land and areas overgrown with weeds and brush, although they may be abundant in moist areas where weeds and brush are practically absent. They are notoriously bad in most areas overgrown with briars or blackberry bushes, but may occur, however, on well-kept lawns, especially the first year or two after an area has been cleared and developed. They are usually more abundant on heavy soils than on light sandy ones.

Seasonal Occurrence. The seasonal activity and abundance of chiggers vary with the latitude and also with the weather conditions. In portions of the country where hard freezes do not occur they may be present, though less abundant, throughout the winter. Somewhat farther north they become active about April, and toward the northern limits of their range, May or later. Their first appearance in spring is usually at the time blackberries begin to bloom. At the latitude of Dallas, Texas, they reach a peak of abundance in early June and their activity continues until heavy frosts occur (usually in November). Hot, dry weather in midsummer reduces their numbers, especially in exposed places.

Hosts. Chiggers are of most importance as pests of man; but horses, mules, dogs, and cats are sometimes annoyed if heavily infested. They attack and seriously injure or kill young chickens, turkeys, and wild birds. They also attack rabbits, and other wild animals.

Stages and Habits. Chiggers are just large enough to be readily seen with the naked eye, and crawl about rapidly. When engorged the body becomes distended and about 1/32 of an inch in length. The red color is usually less intense after engorgement than before. When engorged with the blood of man or some animal the chiggers drop off and later, on the ground, molt. The subsequent stages of the mites are not injurious in any way. They live as scavengers on decaying vegetation. The mites become full-grown in the fall and burrow into the soil from 1/4 to 1 inch and remain there during the winter. In the spring they deposit a mass of eggs. These hatch several weeks later and the young apparently live several months if they do not find a host.

It is a common belief that chiggers burrow into the skin. This is not the case. They attach themselves to the skin, usually close to a hair, and inject an irritating secretion which continues to cause severe itching for several days after they have dropped off or have been removed. Normally

the chiggers become engorged in 4 to 6 days and drop off, but in the case of man they are usually scratched off within a day or two after the itching begins. They may attack any part of the body. As they usually crawl up from the soil and vegetation, however, they are likely to infest the lower extremities most heavily. They are inclined to stop crawling up and attack where there is some obstruction as under hose supporters or belts. They may become well distributed over the entire body in cases where men find it necessary to lie or crawl on the ground. They may occur in the hair of the head, but as a rule are not troublesome there.

Effect of Bite. Few people detect the presence of chiggers until they have been attacked for 2 to 12 hours. Itching usually starts in about that length of time and becomes more intense for the next day or two. Accompanying the itching there usually develop raised whitish wheals from 1/4 to 1/2 inch in diameter with a small reddish area around the chigger which can be seen as a minute red point at the center. Later a small blister develops at the center. These blisters are usually broken and the chigger destroyed by scratching. Then a bright red area remains, and the itching may persist for a period of 4 to 10 days after the infestation occurred. If secondary infection is introduced the lesions may persist for weeks.

Those not familiar with chiggers often mistake an infestation for some disease. The distribution of the spots, the intense itching, the small blisterlike center of the lesion rapidly distinguish infestations from other skin irritations. This is particularly true if an examination be made early while the chiggers are present.

Control. Chiggers are so widespread and develop on so many forms of animal life that it is almost impossible to control them over large areas. Their abundance can be reduced to some extent by clearing out underbrush and keeping grass and weeds cut for a distance of about 50 to 100 feet beyond the desired area.

Recent experiments indicate that emulsion sprays of chlordan or toxaphene applied at the rate of 2 lbs. of toxicant per acre, or lindane emulsion at 1/4 lb. per acre will provide a high degree of control for 1 to 2 months. Four tablespoons of 50 % Chlordan or toxaphene concentrate per gallon of water applied as spray per 100 sq. ft. gives same results. Wettable powder sprays at the above dosages will give protection for 2 to 6 weeks, and dusts for 1 to 4 weeks. Some degree of control of chiggers can be secured by dusting the vegetation and ground thoroughly with 325-mesh sulphur. This treatment is most effective if sulphur be supplemented with the clearing and grass cutting mentioned above. The sulphur should be applied at the rate of 50 pounds per acre with a dust gun. The frequency of such applications should be at intervals of about 2 weeks, beginning at the early part of the chigger season.

The use of repellents against mites was not successful until recently. The best known to date are: diphenyl carbonate, benzil, p-tolyl benzoate, benzyl benzoate, dibutyl phthalate, dimethyl phthalate. (See repellent formulae in this chapter under heading "Repellents".) These are applied to clothes at the rate of 2 grams per square foot of clothes and they give protection for at least 10 days.

Clothing. Closely woven garments with boots worn over the trousers will exclude many of the chiggers. Leggings if properly fitted over the shoes offer much protection, but some find their way under the leggings. Clothing impregnated with 5% water emulsion of benzyl benzoate prevents chigger attacks on man.

Dusting the clothing and body, especially from the waist down, with sulphur gives good protection against these pests. Ordinary flowers of sulphur will suffice, but the finer sulphurs (325-mesh) are better.

One should lightly dust sulphur on the skin, underclothes, and socks before going into chigger-infested areas. The effectiveness of the sulphur increases after it has been applied for 2 to 3 days in succession, at which time it can be relied upon to give reasonably good protection.

There are some who are sensitive to the repeated application of sulphur. If skin eruption results from sulphur, its use should be discontinued. Sulphur is somewhat objectionable because of the odor produced, especially when it is hot and the treated individuals are perspiring. It also discolors gold

and other metal articles.

Personal Measures: When a person is infested with chiggers, the application of benzyl benzoate or sulphur foam will destroy them. Otherwise a warm bath should be taken and all clothing changed. It is well to lather the body thoroughly with a soap containing sulphur or cresol and let the lather remain on 5 to 10 minutes before washing it off. Other soaps are reasonably effective if medicated soaps be not at hand. If there be certainty that chiggers have attached to the skin, a light application of kerosene or pyrethrum-oil fly spray to the body 2 to 3 minutes before bathing is advised. These latter materials may irritate the skin if left on too long. A few spoonfuls of ammonia in the bath will kill the redbugs. There is little that can be done to allay the itching other than to apply cooling lotions such as mentholated ointments or carbolated petrolatum. The application of collodion to each chigger bite is soothing.

House Ants

The true ants belong to the family Formicidae which comprises about 8,000 described species. Ants are mostly pest insects, but some are formidable stingers with potent venom. The latter are found mostly in the tropics. Because of their habits, ants may well be looked upon as potential vectors of typhoid, food poisoning, dysentery, cholera and other types of bacteria.

Several species of ants invade houses and get into foods. They all form colonies or nests in which the queen ants lay their eggs. The workers are the ants that are found attacking foods and crawling about the house. After collecting food, they carry it back to their nest where they feed the queen and the young. Killing some of these workers merely weakens the colony but does not effect the queens or the development of the young, unless so many workers are killed that the colony's food supply is seriously reduced. In fighting ants, therefore, the secret of success is to locate and destroy the nests, including the queens and the young.

Every now and then, particularly late in the winter, in the spring and early summer, ant colonies produce large numbers of winged forms. These are the young queens and the males. They swarm from the old nest, usually in considerable numbers, and attract attention by their abundance. Most of them die without causing injury. Probably not 1 queen in 500 succeeds in establishing a new colony. The winged forms do not return to the old nest. These are differentiated from termites in that the latter are whitish and never are seen running freely about the house or yard. Ants do not bore into good wood, but only into rotted wood.

Ant nests around a house or lawn may be located in any place offering protection. In a house, it may be between floorings, in the wall, behind baseboards, in decayed or defective timber or in the soil beneath a cracked cement cellar floor. Out of doors the nest may be in dry, rotted porch supports or under sills, beneath brick or cement walks, beneath stones, in decaying logs, in cavities, or the softened interior of trees, or merely in the ground itself. When a nest is in the woodwork of the house, the accumulation of sawdust which the ants drop from the infested piece of wood is usually ample evidence of its presence.

Control of Colonies. Ideal ant control is based on the destruction of the queens and the young in the nest itself. If the nest can be found by following back along the line or trail of worker ants as they come to and go from food, it is not difficult to kill the colony, particularly if it be located, as it often is, out of doors or in the soil beneath a cracked cement basement floor.

Ants in and around houses can be controlled by spraying or painting with 2% chlordan oil solution or emulsion on cupboard walls, along the back shelves, work tables, drain boards, window sills and door thresholds and by spraying the underside of the kitchen sink, around and on garbage cans and refuse containers and under refrigerators. A thorough application of 5% chlordan dust, wettable powder or emulsion for a distance of 3 or 4 feet out from the house is effective. For carpenter ants, apply a 2%-5% chlordan oil solution or emulsion thoroughly in tunnels.

Ants in lawns, if colonies be many and widely scattered, can be controlled by dusting the entire area with 5% chlordan. Sprays may also be used. For individual nests, a tablespoonful of BHC powder or chlordan worked into the loose earth of the nest and then slowly soaked with a gallon of water, or suspending the powder in a gallon of water and slowly applying to the nest will give

excellent results.

The above toxicants have, to a large extent, replaced the use of carbon disulphide which is applied at the rate of 2 to 3 tablespoonfuls directly to nests or cracks from which the ants emanate.

Sand Flies or Punkies (Culicoides spp.).

The minute blood sucking gnats are known as sand flies or punkies, or No-See-Ums which are troublesome pests of man and livestock in many parts of the country. There are many different species. All breed in water or very damp places. The larvae of certain species are to be found among leaves and other decaying vegetation or in manure along the margin of streams. Others breed in rot holes in trees that are capable of holding water. The most serious annoyance from these pests occurs along the Atlantic and Gulf Coasts and in the West Indies and Central American countries. These pests breed in the open, grassy salt marshes where the tide is not too active; also in mangrove and picklewood marshes along the Coast of Florida and countries to the south. Breeding is more profuse in areas where fresh water enters the sea.

The eggs are laid on the mud near the water. They hatch in a few days and the slender larvae can either burrow into the thin mud or swim about in the water. The duration of the larval stage varies from a few months to 6 to 8 months. Pupation takes place in the mud. Sand flies apparently do not spread more than two or three miles from their point of emergence.

Control. Sand fly larvae find it difficult to live in dryness, therefore, removal of water from a breeding area is the most satisfactory control. Unlike mosquito larvae, they can live in mud, therefore more complete drying is necessary than is required in mosquito control.

It has been found possible to largely eliminate the pest by construction of dykes, by tide gates or pumping, or both. In order to concentrate the water and more completely dry the dyked area, a ditching system is usually necessary.Since some sand flies develop in the mud along the ditches, the number of ditches should be reduced to a minimum, and these should lead directly into the large band ditch running along the dyke.

Wood adjacent to camps should be inspected and the rot holes found should be cut out so they will drain, or they may be sprayed or painted liberally with creosote oil.

Sand flies can pass readily through ordinary screens and thus they often become very annoying in well screened buildings. DDT and other chlorinated hydrocarbons will kill sand flies. Apply a residual spray to both sides of window and door screens and if necessary to the walls of rooms. Pay particular attention to surfaces about light fixtures. Residual spray to soil if breeding place be known may be of aid. Painting the screens lightly each evening with 1 part of pyrethrum concentrate (2 grams pyrethrum per 100 cc. kerosene) in 20 parts of light lubricating oil (S. A. E. 5) is also effective. Aldrin, dieldrin and heptachlor are effective larvicides. Repellent mixtures may be applied to exposed parts of the body to protect against sand fly attack.

Sand flies are attracted to light to some extent, therefore, on still nights when these gnats are bad, illumination of quarters should be avoided as much as possible.

Phlebotomus Flies.

The Phletobomus flies, popularly though erroneously called "sandflies", include a number of small hairy midges about a pinhead in size (3-5mm.). In most species only the female sucks blood and though the insects are minute their bite causes very severe irritation.

The Phlebotomus papatasii transmit the virus of pappataci fever (sandfly fever); oriental sore (cutaneous leishmaniasis) and probably kala azar.

Life History and Habit. On the slightest disturbance the insect by short rapid flights suddenly moves to the left or right, suggesting to some extent the movement of a flea.Its small size enables it to creep through the mesh of ordinary mosquito nets.

The fly breeds in such places as dark and damp cellars, caves, dugouts, cracks and fissures in soil, under damp stone walls, etc. Moist organic matter is essential as well as shelter and darkness. The latter condition is provided in areas where cracks and fissures are present in the soil. Too much moisture drowns the larvae and it may be accepted that material for a possible breeding place is too damp if it adheres to fingers and does not just fall off when rubbed gently between them. The eggs are deposited 40 to 50 in number and they hatch in 4 to 15 days, giving rise to minute caterpillar-like larva whose body shows, according to the stage of development, one or two pairs of long bristles at the posterior end.

The larvae lives on organic matter and when fully grown, in 8 to 28 days, they pupate and the adult insect emerges some days later. The larvae die very quickly in dry or very wet soil.

The adult flies find shelter in clods of earth, beds of streams and in holes in trees. It is worthy of note that they may be carried in timber and other cargo from place to place by seagoing vessels.

Toward evening the flies sally forth upon the blood quest. The female alone is a blood sucker and feeds principally in the gloaming at dawn. They chiefly attack the wrists and the ankles and can easily bite through thin socks or light cotton or linen clothing. A single fly may make many punctures. It becomes sluggish after several suctions.

At sunrise the flies vanish, either retiring to their breeding haunts or seeking dark corners in rooms or dugouts. They dislike sunlight but are attracted by lamps and candles. It is probable that they rarely traverse more than fifty yards or so and they do not fly high.

The bites are painful and when numerous the bitten part may be badly swollen, resembling those of chickenpox.

Control. To control these midges the following measures should receive special attention:

1. Removal of all rubbish, especially heaps of rubbish for a distance of 100 to 300 yards around habitations.
2. Levelling the ground by rolling and, in special cases, by rendering the surface impermeable with cement, asphalt, tar or similar material.
3. Facing and painting of walls of buildings in which crevices have appeared which are likely to afford breeding places for the insects.
4. The eradication of cracks and crevices in the banks of streams, drains, etc. by smoothing off the surface or lining with cement or concrete.

To deal with the adult fly in houses, the use of residual DDT and other chlorinated hydrocarbon sprays should be tried as recommended for sand flies. Destruction is easily effected by the use of pyrethrum fly spray. Repellent mixtures may also be applied to exposed parts of the body to protect against attack. As much natural lighting as possible should be provided and ventilation and air movement should be satisfactory. When electric fans are employed, they should be directed against the open window.

Eye Gnats.

Eye gnats (Hippelates) commonly called frit flies are very small (about 1/16 inch long) flies that have a strong tendency to hover around the face and eyes of people and also to visit food to some extent. They are strongly attracted to wounds and discharges from natural body openings and also feed upon decaying organic matter, hence they are capable of taking and transferring many kinds of germs. There are strong indications that they are responsible for much eye infection especially epidemics of pink eye among school children, and may transmit the serious tropical disease of man called yaws. They are so small that they can pass through ordinary screens with ease.

Eye gnats are most abundant in the southern portions of the country, and in the irrigated areas in the Southwest they may occur in alarming numbers. These gnats (Hippelates pusio Loew) are particularly annoying during March, April, May and again during August, September and October. They are noticable early in the mornings and late in the afternoon and in deep shade. Eggs are about 0.5 mm. in length and are deposited on decaying organic matter. The incubation period of the eggs is about 3 days. The larvae feed on a great variety of decaying organic matter including

excrement, provided the material be rather loose and well aerated and if it be excrement, that it be mixed with earth. The larval stage under optimum conditions requires about 11 days, but may remain in this stage during the winter. Pupation takes place close to the surface of the material and requires about 6 days, giving a total of about 21 days from egg to adult fly. It appears that most of these gnats breed in soil that is (1) light and friable (well drained), (2) freshly plowed (i. e., plowed not over three weeks before), and (3) contains abundant humus or vegetable matter (cover crops, manure).

Control: There is no single measure that has proved universally effective in control. Sanitation is important, such as removal of garbage, manure piles, refuse heaps etc., and decaying organic matter. Traps of a special design, placed around the camp in places where gnats occur in greatest numbers will reduce gnat abundance to a large extent. Systematic operation of traps around schools has been shown to aid materially in the reduction of the incidence of purulent conjunctivitis (pink eye).

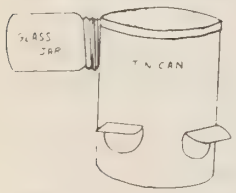


Figure 13.
An improvised eye gnat trap. Liver and water bait is placed in the bottom of the can, and gnats, after feeding, enter the jar and die.

Of the newer insecticides, aldrin and heptachlor have been found to be effective larvicides for eye gnats. DDT residual spray should be tried on screens and walls as in the control of the house fly. Space spraying should also be used. Fly sprays (pyrethrum in oil) kill the gnats actually struck and repel others for a short time. 1 part pyrethrum concentrate (composed of 2 grams of pyrethrum per 100 c. c. of kerosene) and lubricating oil (No. 10), 20 parts, lightly painted on window screens will keep gnats out for several hours.

Chart 4

Classification of Arthropods of North America Which are Actual or Potential Reservoirs, Vectors, or Causative Agents of Disease in Man

CLASS	ORDER	FAMILY	GENUS	SPECIES	COMMON NAME OF SPECIES	DISEASES - USUAL AND POTENTIAL
Arachnida	*Acarina* (TICKS AND MITES)	*Argasidae* (SOFT TICKS)	*Ornithodorus*	*O. coriaceus*	PAJAROELLA	TICK BITE POISONING
				O. hermsi		RELAPSING FEVER, Q FEVER
				O. parkeri		TULAREMIA
				O. talaje		TICK BITE POISONING, RELAPSING FEVER
				O. turcata		TICK BITE POISONING, RELAPSING FEVER, TULAREMIA, TRYPANOSOMIASIS, Q FEVER
				O. venezuelensis		TICK BITE POISONING, RELAPSING FEVER
		Ixodidae (HARD TICKS)	*Amblyomma*	*A. americana*	LONE STAR TICK	ROCKY MOUNTAIN SPOTTED FEVER, TULAREMIA
			Boophilus	*B. annulatus*	TEXAS CATTLE FEVER TICK	ANAPLASMOSIS
			Dermacentor	*D. andersoni*	WOOD TICK	ROCKY MOUNTAIN SPOTTED FEVER, TICK PARALYSIS, COLORADO TICK FEVER, TULAREMIA, ANAPLASMOSIS, VIRUS ENCEPHALITIS, LYMPHOCYTIC CHORIOMENINGITIS, Q FEVER
				D. accidentalis	PACIFIC COAST TICK	ROCKY MOUNTAIN SPOTTED FEVER, TULAREMIA
				D. variabilis	DOG TICK	ROCKY MOUNTAIN SPOTTED FEVER, TULAREMIA, ANAPLASMOSIS
			Haemaphysalis	*H. leporis-palustris*	RABBIT TICK	ROCKY MOUNTAIN SPOTTED FEVER, TULAREMIA,
			Ixodes	*I. ricinus*		TICK BITE POISONING, TULAREMIA, ANAPLASMOSIS, LOUPING ILL
		Dermodicidae	*Dermodex*	*D. folliculorum*	FACE OR BLACKHEAD MITE	COMEDONES, ACNE-LIKE CONDITIONS
		Dermanyssidae	*Allodermanyssus*	*A. sanguineus*	RODENT MITES	RICKETTSIALPOX
			Dermanyssus	*D. gallinae*	CHICKEN MITES	SKIN IRRITATIONS, ST. LOUIS ENCEPHALITIS, EQUINE ENCEPHALOMYELITIS
				D. hirundinus		SKIN IRRITATIONS
			Liponyssus	*L. bacoti*	TROPICAL RAT MITE	SKIN IRRITATION, TYPHUS
				L. bursi	TROPICAL FOWL MITE	SKIN IRRITATION, EQUINE ENCEPHALOMYELITIS
				L. sylviarum	WILD BIRD MITE	EQUINE ENCEPHALOMYELITIS
		Sarcoptidae	*Sarcoptes*	*S. scabies*	ITCH MITE	SCABIES

		Tarsonemidae	*Pediculoides*	*P. ventricosus*	GRAIN MITE	STRAW ITCH
		Tetranychidae	*Tetranychus*	*T. telarius*	RED SPIDER	ITCH
		Trombidiidae	*Trombicula*	*T. irritans*	RED BUG	HARVEST ITCH
		Tyroglyphidae	*Glyciphagus*	*G. prunorum*	GROCER'S ITCH MITE	
			Tyroglyphus	*T. americanus*	CEREAL MITE	GROCER'S ITCH
				T. farinae	FLOUR MITE	
				T. longior	COPRA ITCH MITE	COPRA ITCH
				T. siro	CHEESE MITE	VANILLISM
	Araneida (SPIDERS)	*Theridiidae*	*Latrodectus*	*L. mactans*	BLACK WIDOW SPIDER	SPIDER BITE POISONING
	Scorpionida (SCORPIONS)	*Buthidae*	*Centruroides*	*C. suffusus*	DURANGO SCORPION	SPIDER BITE POISONING
				C. vittatus	STRIPED SCORPION	SPIDER BITE POISONING
Crustacea (AQUATIC ARTHROPODA MOSTLY)	*Copepoda*	*Cyclopidae*	*Cyclops*	*C. brevispinosus*	CYCLOPS OR LITTLE WATER FLEAS	FISH TAPEWORM
				C. prasinus		FISH TAPEWORM
		Diaptomidae	*Diaptomus*	*D. oregonensis*		FISH TAPEWORM
Insecta OR *Hexapoda* (INSECTS)	*Anaplura* (SUCKING LICE)	*Pediculidae*	*Haemodipsus*	*H. ventricosus*	RABBIT LOUSE	TULAREMIA
			Pediculus	*P. capitis*	HEAD LOUSE	TYPHUS FEVER, RELAPSING FEVER, TRENCH FEVER
				P. corporis	BODY LOUSE	TYPHUS FEVER, RELAPSING FEVER, TRENCH FEVER
			Phthirus	*P. pubis*	CRAB OR PUBLIC LOUSE	TYPHUS FEVER, RELAPSING FEVER, TRENCH FEVER
	Coleoptera (BEETLES)			MANY SPECIES		RAT TAPEWORM, GONGYLONEMIASIS, MONILIASIS
	Dermaptera (EARWIGS)	*Forficulidae*	*Anisolabis*	*A. annulipes*	RING-LEGGED EARWIG	RAT TAPEWORM
	Diptera (FLIES AND MOSQUITOES)	*Anthomyiidae*	*Anthomyia*	*A. canicularis*	LITTLE OR LESSER HOUSEFLY	URINARY MYIASIS
				A. scalaris	LATRINE FLY	URINARY MYIASIS
		Calliphoridae (BLOW FLIES)	*Calliphora*	*C. vomitoria*	BLOW FLY OR BLUEBOTTLE FLY	TRAUMATIC DERMAL MYIASIS
			Cochliomyia	*C. americana*	SCREW-WORM FLIES	INTESTINAL MYIASIS, TRAUMATIC DERMAL MYIASIS
				C. macellaria	SCREW-WORM FLIES	INTESTINAL MYIASIS, TRAUMATIC DERMAL MYIASIS
			Lucilia	*L. caesar*	GREEN BOTTLE FLIES	NASOPHARYNGEAL MYIASIS, TRAUMATIC DERMAL MYIASIS
				L. sericata	GREEN BOTTLE FLIES	NASOPHARYNGEAL MYIASIS, TRAUMATIC DERMAL MYIASIS
		Ceratopogonidae (BITING MIDGES)	*Culicoides*	*C. furens*	PUNKIES OR NO-SEE-UMS	MICROFILARIASIS, SKIN IRRITATIONS

Culicidae (MOSQUITOES)	*Aedes*	*A. aegypti*		YELLOW FEVER, DENGUE FEVER, EQUINE ENCEPHALOMYELITIS, LYMPHOCYTIC CHORIOMENINGITIS
		A. atropalpus		EQUINE ENCEPHALOMYELITIS
		A. dorsalis		EQUINE ENCEPHALOMYELITIS, ST. LOUIS ENCEPHALITIS
		A. lateralis		ST. LOUIS ENCEPHALITIS
		A. nigromaculis		EQUINE ENCEPHALOMYELITIS, ST. LOUIS ENCEPHALITIS
		A. taeniorhynchus		ST. LOUIS ENCEPHALITIS
		A. triseriatus		EQUINE ENCEPHALOMYELITIS
		A. vexans		ST. LOUIS ENCEPHALITIS
	Anopheles	*A. albimanus*		MALARIA
		A. freeborni		MALARIA, EQUINE ENCEPHALOMYELITIS
		A. quadrimaculatus		MALARIA
	Culiseta	*C. inorata*		EQUINE ENCEPHALOMYELITIS
	Culex	*C. pipiens*		FILARIASIS
		C. quinquefasciatus		FILARIASIS, ST. LOUIS ENCEPHALITIS, EQUINE ENCEPHALOMYELITIS
		C. stigmatosoma		EQUINE ENCEPHALOMYELITIS
		C. tarsalis		EQUINE ENCEPHALOMYELITIS, ST. LOUIS ENCEPHALITIS
Gastrophilidae (HORSE BOTFLIES)	*Gastrophilus*	*G. intestinalis*	NOSE FLY OR RED TAILED BOT	INTESTINAL AND ANAL MYIASIS, CREEPING CUTANEOUS MYIASIS
		G. nasalis	CHIN OR THROAT BOTFLY	
Muscidae (HOUSE FLIES)	*Musca*	*M. domestica*	COMMON HOUSE FLY	TYPHOID FEVER, ANTHRAX, DYSENTERY, CHOLERA, TUBERCULOSIS, EYE INFECTIONS, INFANT DIARRHEAS URINARY MYIASIS, AND ALL TYPES OF INTESTINAL DISEASES INCLUDING VARIOUS TYPES OF WORMS
	Phormia	*P. regina*		TRAUMATIC DERMAL MYIASIS
	Stomoxys	*S. calcitrans*	STABLE OR BITING HOUSE FLY	TULAREMIA, TRYPANOSOMIASIS
Oestridae (BOTFLIES AND WARBLE FLIES)	*Dermatobia*	*D. hominis*	BOTFLY	DERMAL CREEPING MYIASIS
	Hypoderma	*H. bovis*	BOMB-FLY	
		H. lineatum	HEEL-FLY	
Oscinidae OR *Chloropidae* (EYE GNATS)	*Hippelates*	*H. pallipes*	EYE GNATS OR FRIT FLIES	PINK EYE, YAWS
		H. pusio		
Piophilidae	*Piophila*	*P. casei*	CHEESE FLY	INTESTINAL MYIASIS
Sarcophagidae (FLESH FLIES)	*Sarcophaga*	*S. carnaria*	FLESH FLIES	VAGINAL MYIASIS
		S. hemorrhoidalis		INTESTINAL MYIASIS
Simulidae (BLACK FLIES OR BUFFALO GNATS)	*Eusimulium*	*E. avidum*	BUFFALO GNATS OR BLACK FLIES	ONCHOCERCIASIS
		E. mooseri		
		E. ochraceum		
Stratiomyiidae	*Hermetia*	*H. illucens*	SOLDIER FLY	INTESTINAL MYIASIS
Syrphidae	*Eristalis*	*E. tenax*	DRONE FLY	GASTRIC MYIASIS

	Tabanidae (HORSE FLIES)	*Chrysops*	*C. discalis*	DEER FLY	TULAREMIA, ANTRHAX
Hemiptera OR *Heteroptera* (TRUE BUGS)	*Cimicidae* (BED BUGS)	*Cimex*	*C. lectularius*	BED BUG	ARE ABLE TO SPREAD TULAREMIA, PLAGUE, ICTEROHEMORRHAGIC JAUNDICE, RELAPSING FEVER, TRYPANOSOMIASIS
	Reduviidae	*Arilus*	*A. cristatus*	WHEEL BUG	BITE POISONING
		Rasahus	*R. thoracicus*	TWO SPOTTED CORSAIR	
		Reduvius	*R. personatus*	KISSING BUG	
		Triatoma	*T. dimidiata*		TRYPANOSOMIASIS
			T. protracta	CHINA BED BUG	TRYPANOSOMIASIS, BITE POISONING
			T. sanguisuga	ASSASSIN BUG	TRYPANOSOMIASIS, BITE POISONING, VIRUS - ENCEPHALITIS
Hymenoptera	*Formicidae* (ANTS)	*Camponotus*	*C. herculeanus pennsylvanicus*	CARPENTER ANT	POTENTIAL TRANSMITTERS OF MOST OF THE DISEASES THAT THE HOUSEFLY IS CAPABLE OF TRANSMITTING
		Iridomyrmex	*I. humilis*	ARGENTINE ANT	
		Lasius	*L. interjectus*		
		Monomorium	*M. minimum*		
			M. pharaonis	PHARAOH'S ANT	
		Solenopsis	*S. molesta*	THIEF ANT	
			S. xyloni	CALIFORNIA FIRE ANT	
		Tetramorium	*T. caespitum*	PAVEMENT ANT	
Lepidoptera (MOTHS AND BUTTERFLIES)			SOME SPECIES OF GRAIN MOTHS		RAT TAPEWORM
Mallophaga (BITING LICE)	*Trichodectidae*	*Trichodectes*	*T. canis*	BITING DOG LOUSE	DOG TAPEWORM
Orthoptera	*Blattidae* (COCKROACHES)	*Blatta*	*B. orientalis*	ORIENTAL COCKROACH	POTENTIAL TRANSMITTERS OF MOST OF THE DI: THAT THE HOUSEFLY IS CAPABLE OF TRANSM PLUS GONGYLONEMA AND RAT TAPEWORM
		Blattella	*B. germanica*	CROTON BUG, OR GERMAN COACK ROACH, OR WATER BUG	
		Periplaneta	*P. americana*	AMERICAN COCKROACH	
			P. australasiae	AUSTRALIAN COCKROACH	
		Supella	*S. supellectilium*	TROPICAL COCKROACH	
Siphonaptera (FLEAS)	*Ceratophyllidae* OR *Dolichopsyllidae*	*Ceratophyllus*	*C. acutus*	GROUND SQUIRREL FLEA	PLAGUE, TULAREMIA
			C. fasciatus	COMMON RAT FLEA	PLAGUE, TYPHUS
			C. idahoensis	GROUND SQUIRREL FLEA	PLAGUE
	Echidnophagidae OR *Hectopsyllidae*	*Echidnophaga*	*E. gallinacea*	STICKTIGHT FLEA	SKIN IRRITATION AND INFECTION, ST. LOUIS ENCEPHALITIS
		Tunga	*T. penetrans*	CHIGOE OR JIGGER	PENETRATES SKIN PRODUCING INFECTION

		Pulicidae	*Cediopsylla*	*C. inaequalis*	RABBIT FLEA	TULAREMIA
			Ctenocephalus	*C. canis*	DOG FLEA	TRYPANOSOMIASIS, DOG TAPEWORM, RAT TAPEWORM
				C. felis	CAT FLEA	
			Pulex	*P. irritans*	HUMAN FLEA	PLAGUE, TULAREMIA, TYPHUS, DOG TAPEWORM, TRYPANOSOMIASIS, LEISHMANIASIS
			Xenopsylla	*X. cheopis*	INDIAN RAT FLEA	
Myriapoda (CENTIPEDES)	*Chilopoda*	*Scolopendridae*	*Scolopendra*	*S. heros* *S. polymorpha* *S. sumichrasti* *S. viridis*	THOUSAND LEGGERS	BITE POISONING
Pentastomida	*Porocephalida*	*Linguatulidae*	*Linguatula*	*L. serrata*	TONGUE WORM	PENTASTOMIASIS

Chapter VIII.

RODENT CONTROL

General Considerations.

Rodent control is based on the knowledge of the biologist, the architect, the chemist, the engineer, the pharmacologist, the veterinarian and probably others. The application of this knowledge involves unskilled, semiskilled, skilled and professional workers. The immediate direction of control programs is the sanitarian's province. In order for the sanitarian to grasp the rationale of rodent control, it is imperative for him to study the habits and life cycle of the particular rodents in relation to the particular ecological conditions. The application of this knowledge requires the sanitarian to learn some of the practical elements of carpentry, concrete making, building and boat construction, use of machines such as tractors and power pumps, mixing and handling of poisons, food storage and transportation, estimating costs and quantities of materials and labor, handling ectoparasites, bleeding rodents and a host of other things besides the usual public health techniques. If ever a sanitarian had an opportunity to show how much all-around skill he possesses, it is in this phase of the sanitary program.

Domestic and wild rodents have been considered as pests during the whole period of civilization. In recent decades a number of them have been inplicated and some of them proved to be reservoirs of disease. Today we know of at least 8 diseases which are found in rodents and in humans, some of which have been definitely shown to be transmitted from rodent to man. The number of species of rodents which appear to be reservoirs of diseases transmitted to man are many; for example, over 80 types of rodents have been found naturally infected with plague and it has been proven that the rat flea is the common vector of the disease from rat to rat, and can be the vector from rat to man. Of all the rodents, it appears from present knowledge that the rat which lives so closely to man is the most important with which man must do battle. Murine typhus fever is commonly transmitted from rat to rat by the flea and is presumable transmitted from rat to man by the rat flea or other rat ectoparasites. It appears that rickettsialpox is transmitted by the mouse mite to man. There is also circumstantial evidence that the latter is true for the disease, lymphocytic choriomeningitis. Endemic relapsing fever in western United States has its reservoir in a variety of rodents such as the chipmunk, ground squirrel, prairie dog, kangaroo rat, white mouse, and other burrowing rodents. It is transmitted from animal to animal and from animal to man by the argasive tick, genus Ornithodorus. Rocky mountain spotted fever has its reservoir in wild rodents. It is transmitted from animal to animal and animal to man by the ixodine tick, usually the genus Dermacentor. The reservoir of jungle yellow fever in South America is wild rodents and other animals, and is presumably transmitted from animal to animal and animal to man by a variety of mosquitoes. Rat-bite fever and Haverhill fever are transmitted by the rat bite. Icterohemorrhagic jaundice (leptospirosis or Weil's disease) is transmitted usually by contamination of water supplies by the excreta of rats. Food poisoning (salmonellosis) and tapeworm (hymenolepiasis) are transmitted by contamination of food by rat droppings. Another disease for which the rat serves as reservoir is trichinosis, but in this case the disease is transmitted to man indirectly through pigs that devour the carcasses of diseased rats. The whole story of the role of rodents as carriers of disease to man is yet untold.

Rats cost the United States $500,000,000 every year. A rat eats and destroys $200 worth of food annually. They are the most destructive animals in the world. Rats have been responsible for more deaths among human beings than all the wars of mankind. The rats could produce 359,000,000 descendents in 3 years if conditions were favorable for them and no deaths occurred. They migrate freely from farm to farm and house to house.

Rats produce about 3 to 8 litters annually and about 6 to 14 young per litter. The seasons of maximum reproduction are spring and fall. The gestation period averages about 25 days. They become independent of the mother rat in 4 to 5 weeks, become sexually mature in about 4 months, and continue to grow until 18 months. The average duration of life is between 3 and 5 years. Considering a 30% mortality rate among young rats, it is estimated that each female weans about 20 rats per year.

The various methods of rat extermination which have in the past been employed are: natural

enemies, fumigation, poisons, traps, and similar means. Some of these methods have proved satisfactory to a limited extent, but none have served with telling effect. The reason attributed to this failure is that the fundamental factors involved in effective rat control were not used. These are the control of available food for rat survival and the control of rat harborage, i. e., the enclosed spaces which afford rats hidden or partly hidden shelter, and suitable facilities for breeding and protecting their young until maturity. The control of rodents other than rats is still in the experimental stage. The discovery of new poisons recently has given stimulus to field rodent control work.

Rodent population trends show that house mice are increasing as the rat population is being controlled. In the Southern States, the control of the Norway rat population has led to a relative increase of the black rat population.

In order for any program of rat control to be effective, the techniques applied must be carried out continuously and must give more or less permanent results.

Habits and Characteristics of Rats.

Rats are nocturnal animals. In day light, they move slowly and with uncertainty unless they be close to walls along which they can run while their feelers make contact. They prefer narrow passages and runways along walls. An important trait is that they migrate according to variation in abundance and accessibility of food and availability of shelter. Such migrations may be seasonal, for example, from buildings to fields in the spring, and back to the buildings in autumn. Sometimes they may vacate buildings permanently because of lack of food. Migration may take place in groups or as individuals. All rats, especially the brown rat, travel on ships, trains, or other vehicles which carry with them good edible food. The brown rat is more ferocious than other rats. It will attack the black rat and roof rat and drive them out of the vicinity or to upper floors where it cannot follow easily, since it is a burrowing rather than a climbing rat. As a result of this aggressiveness and also its greater fecundity, the brown rat is widespread in the world while the black rat seldom goes far from seaports. The principle harboring places of rats are buildings, ships and vehicles where plenty of edible food is around; and under stables, in dumps, warehouses, store-rooms or empty buildings close to a food supply, and in burrows under walks. Rats are very selective about their food. They, like humans, prefer fresh, wholesome, non-decomposed food. Rats are omnivorous, but may have capricious appetites.

There are 4 types of rats usually found in the United States. The 2 most common species are the brown rat, (Rattus norvegicus), or Norway rat or sewer rat, and the black rat, (Rattus rattus rattus). Less frequently is found the roof rat, (Rattus rattus alexandrinus), or Alexandrine or Egyptian or the grey-bellied rat, and the white-bellied rat, (Rattus rattus frugivorus).

Brown rat: This rat lives mostly in the temperate zone. It is a burrowing animal, living in holes rather than buildings above ground. Its burrows are about 12 inches below the surface and seldom reach 18 inches in depth. It is capable of burrowing through hard packed clay or even lime mortar and sand between bricks or stones of walls. It can gnaw holes in lead pipes and slate. This rat climbs poorly, jumps poorly, and is clumsy. It produces 3 to 5 litters a year, each litter averaging 8 to 10 rats, about one-half of which survive to maturity. The number of litters and the number of rats per litter increase above average when food is ample and the climate and shelter favorable. Like the human, it becomes a scavenger in the absence of fresh, wholesome food. This rat is found all over the United States.

Black rat: This rat does not ordinarily live in burrows, but prefers hollow spaces in walls, or rubbish boxes, barrels, and other containers, attics or upper stories, and trees. It can climb pipes, ropes, wires, or wooden uprights. It produces about 6 rats per litter and is less fecund than the brown rat. It prefers clean food such as grain. This rat is primarily a house rat and is found more frequently in northern United States.

Roof Rat or grey-bellied rat has been confused with the white-bellied rat until recently. That is probably the reason why its habitat has been considered as dual, living in houses and in fields. The grey-bellied rat has a brown back and grey-belly. The two colors gradually blend into one another

without any line of demarcation. It is primarily a house rat and is found more frequently in Southern United States.

White-bellied Rat: This rat has a brown back and a white or lemon yellow belly. The two colors are sharply set off by a rather distinctive line of demarcation. This rat is primarily an out-door rat and does not live close to man. Its favorite nesting place is in the trees. Occasionally only, it is found in barns and houses during the winter season when food outdoors is scarce. The ordinary methods of rat control will be effective against the first 3 rats here described but not against the white-bellied rat due to its habit of naturally nesting in trees.

Mice: There are 4 subspecies of wild house mice belonging to the species Mus musculus Linnaeus, of which three forms have long been associated with human habitation. The subspecies Mus Musculus wagneri has evolved two commensal forms, Mus musculus domesticus and Mus musculus brevirostris which were imported from Europe to the United States, the former being found in the Northern States and the latter, a smaller type, being found in the Southern States. The wild forms of these two types of rodents have white bellies and shorter tails whereas the two commensals have grey bellies and longer tails. There are, however, besides these, about 250 different forms of native mice in North America among which are the very prevalent meadow and white-footed mice. House mice vary widely in color, but generally are characterized by tawny to dark grey fur on the back, the color gradually changing to ashen grey on the abdomen. Their eyes are smaller than the native white-footed type, feet are shorter, broader and darker, the tail shorter. House mice all have very nearly the same habits.

House mice are equal in economic liability to the rat and are responsible for transmitting several forms of food poisoning, also typhus, plague, rickettsialpox, and in causing much contamination of food. They may serve as minor hosts to the tick responsible for spreading spotted fever, and can carry (experimentally) tularemia. They have been incriminated as a reservoir for the virus of lymphocytic choriomeningitis. Some evidence associates them with bacillary dysentery, rabies, swine ersipelas, and infectious hepatitis. Each litter averages 6 to 8 young. The female may produce 6 to 10 litters per year. The average gestation period is about 3 weeks. The young are born blind, hairless, and pink and are found in nests of shredded paper, cloth, etc. They open their eyes in about 2 weeks, become independent of their mother in almost 3 weeks, and become sexually mature in 2 to 3 months, and seldom live longer than a year under normal conditions. They have keen senses except sight, are highly nervous, good natured, excellent climbers and jumpers, and good swimmers. They are able to flourish in extremely hot or cold temperatures, and can exist in a wide variety of habitats ranging from tunnels beneath foundations to boxes of stored goods left in attics. They can gain access to buildings through openings 1/2 inch in diameter and are transported along with contents of boxes and crates, infestations frequently appearing almost overnight. Although omnivorous, and even known to eat various household insects, their preferred foods are many types of seeds, grain and cereal products. They are fond of cornmeal, rolled oats, apple, sweet potato, flower seed, bacon, peanut butter, nut meats, sweet chocolate, etc. They are light, intermittent, and eratic feeders, feeding 15 or 20 times daily and consume about 0.1 to 0.2 grams at each feeding. They are able to exist for more than 4 months without water. When food is plentiful, their range of movement is very limited. Ordinarily, they move in a range of 10 to 25 ft. radius. Evidence of their presence is the small droppings, damage marked by little holes and other gnawing, their squeaking and scampering sounds. A rather disagreeable pungent, musty manure odor is often noticed in buildings which harbor heavy infestations.

Developing Control Programs.

Classification of Control Methods: The methods of Rodent Control may be classified as follows according to the technique applied:

1. Prevention or Control of Rat-Harborage by:
   a. Rat-proofing of building
   b. Vent-stoppage
   c. Storage and removal of refuse.
2. Destruction of Rats by:
   a. Trapping
   b. Poison bait
   c. Fumigation
   d. Natural enemies.

Preliminary Steps: Various administrative steps, procedures and activities which will help to promote a successful rodent control campaign are:

Trained leadership, office space and equipment, field equipment, records, competent surveying, trapping for the purpose of identifying and classifying rodents and their ectoparasites, rat-proofing ordinance, cooperation with other departments, adequate enforcement of provisions, and permanent control measures.

Before any rodent control measures are attempted, the area should be surveyed in order to understand the nature of the problem. Such preliminary steps should include the following:

1. Preliminary Survey:
   a. Cases of rodent-borne diseases should be studied as to location, and spot maps prepared.
   b. Prevalence of rodents and fleas according to species should be determined.
   c. The locations of the main foci.
   d. The presence of potential or used rat and mice runs.
   e. The presence and accessibility of food attractive to rodents, either within buildings or on premises.
   f. Trash or rubbish which might afford harborage for rodents.
   g. Ground burrows present and locations.
   h. Method of garbage disposal, whether buried or stored in rat-proof containers.
   i. If the town be a seaport, the potential hazards of rodent migration from boats to the shore should be surveyed.
   j. Condition of buildings and their state of repair.
   k. Types of building, whether wood, brick, cement, stone, etc., and types of harborages.
   l. Presence or absence of basements and locations when present.
   m. Nature of businesses in area.
   n. Economic status of area.
   o. Estimate of amount of cost of materials for each building and for entire program.

2. Method of Financing Program. Three methods are feasible:
   a. Local government or other agencies provide revolving fund for labor and material. Individual merchant pays into the revolving fund for labor and materials expended on his property.
   b. Municipalities furnish labor and individual merchant furnishes material.
   c. Individual merchant furnishes all labor and material.

The first method is best since it makes uniformity of workmanship and shortest time for completion of work. The second method insures uniform workmanship, but delays completion of program. Third method induces non-uniformity of workmanship and delay in completion of program.

3. Education. All means of bringing the public health aspects of such a program to the people should be used. The population must be interested and willing to accept such work.

Rat-proofing of any type may not be completely successful until the general public is educated to its advantages, until schools and colleges teach its importance to architects and engineers, and until builders, contractors, plumbers, electricians and other building trades workers become conscious of its advantages.

4. Development of Government Support. A well organized and respected health department should encourage the adoption of ordinances which would aid in carrying through the program and which would aid in preventing new conditions of rat-harborage from developing.

Rat-proofing of Buildings. Technically, rat-proofing is the application of 4 fundamental rules in construction and upkeep of building structure and equipment:

1. Employing an approved rat-proof design that fundamentally eliminates unnecessary enclosed spaces.
2. Using material of rat-proof character.
3. Employing approved rat-proof methods of construction and installation.
4. Providing for periodic inspection of building and equipment to insure permanent upkeep.

Rat-proofing is based on the knowledge of the habits of rats in choosing their habitats for reproduction and raising their young.

There are three general types of rat-harborage.

a. Structural:- Examples of which are double walls, spaces between floors and ceilings, hollow-tile partitions, enclosed stairways, hollow-box moulding, raised platforms, and similarly protected places.

b. Incidental:- Examples of which are furniture and equipment, things that are incidental to the use that is made of a building or its subdivisions and are installed therein.

c. Temporary:- Examples of which are mass storage of material or merchandise, rubbish heaps, old furniture, odds and ends piled in cellars, attics, and closets, and similar accumulations which if left undisturbed for periods of several weeks, can and will be used by rats for homes and breeding places.

Rat-harborage is to be found in the great majority of buildings of the older type, and in some buildings of modern construction, and in a great many styles of furniture and equipment which are installed in mercantile and manufacturing establishments. In the majority of instances rat-harborage exists because little or no consideration has been given by the owners, the architects, the builders, or the authorities to the desirability or necessity or providing for its elimination at the time the building was designed, planned, and constructed. As a result, man has provided and continues to provide rats with enclosed spaces ideally adopted for homemaking; the same may be said of certain types of fixtures and equipment. In other words, man himself thoughtlessly establishes rat sanctuaries and gives the matter no further thought until the rodents become so plentiful that they must be killed off or reduced in numbers.

Rat-proofing, then, depends upon:

a. Whether the rat-harborage is to be prevented in the architect's original planning of the building.

b. Whether the buildings are old or new. This may determine the techniques to be used.

c. The cost of the project and the economic status of the community.

d. Influence of Public Health authorities directing community efforts.

The rat-proofing of old or new buildings requires a good deal of thought on the part of the Sanitarian. Usually new buildings lend themselves better to rat-proofing since their materials are usually in better repair and are better preserved, and since it pays to spend more money on a newer building. Therefore, reconstruction is much more applicable to new buildings than to old buildings.

Estimating Costs:

General Rules: 1. All work must be done in compliance with existing building ordinances, codes and regulations, and with existing health department regulations.

2. Any work which may involve the fire department and its regulations must be approved in writing by the fire department and a signed copy filed in the health department office.

3. All construction must be such as not to add to any hazards already present.

4. All species of rats must be considered when protection for a building is being planned.

5. As a general guide it should be assumed that rats can do the following:

   a. Gain entrance through openings larger than 1/2-inch square.
   b. Climb both horizontal and vertical wires not within 3" of the nearest parallel surface.
   c. Climb the inside of vertical pipes one and one-half to 4 inches in diameter.
   d. Climb the outside of vertical pipes and conduits up to 3 inches in diameter.
   e. Climb vertical outside pipes and conduits of any size if within 3 inches of a wall.
   f. Crawl horizontally on any type of pipe or conduit.
   g. Jump vertically as much as 36 inches from a flat surface.
   h. Jump horizontally 48 inches if on a flat surface.
   i. Jump horizontally at least 8 feet from an elevation 15 feet above the finish point.
   j. Reach horizontally 18 inches.
   k. Reach vertically 18 inches.
   l. Drop 50 feet without being killed.

6. Ratproofing repairs must not add to the problems of lighting and ventilation. All openings

must be treated to provide the same amount of ventilation after treatment as before.

7. All workers engaged in ratproofing should be liable for any damage to utility wires by rat guards. Removal or moving of wires must be done only with written permission of the utility owning the wire.

8. Treatment on premises which serve food should provide:

a. That necessary fly screens be combined with hardware-cloth screens at time of manufacture and installation.

b. Hardware cloth in sheet metal frames used over force-fan ventilators must be made of hardware cloth having a mesh of one-half by one-half inch. Frames over ventilators should be made so as to be easily removed from the building face for cleaning off accumulated grease or dirt.

9. a. All stacked refuse, debris, or merchandise which is harboring rats must be cleaned up.

b. Merchandise that contributes to rat infestation must be kept on shelves or racks. All shelves must be kept away from walls and at sufficient distance above the floor to provide for easy cleaning and inspection. A distance of 12 inches from floor to first shelf is preferable.

10. The estimator should show the following information on estimate sheets:

a. Occupant's and owner's name and address. Contractor's name and address. Date contractor intends to start ratproofing.

b. A number, which should be placed on the building near the place where ratproofing is to be done. This number should agree with that on the estimate sheet which gives a full description of the location and a brief outline of methods to be used.

c. Estimate sheets should show the actual sizes for rat guards and their exact position.

d. Estimate sheets should show all work considered necessary to ratproof the property as judged by the estimator from his original or later inspection. This should be the minimum needed for acceptance by the health department.

Construction Rules: 1. All work should be done with materials and workmanship for permanent construction as that term is understood by the construction industry.

2. Sheet metal should be galvanized and not lighter than 26 gauge.

3. Hardware cloth to be galvanized after weaving and the largest openings not more than one-half by one-half inch.

4. All doors in rear entrances should be channeled and cuffed, except close-fitting metal doors. Door casing or jambs are to be flashed.

5. Front and side doors presenting a gnawing edge must be protected by kick plates, thresholds, or combinations thereof, or be channeled and cuffed.

6. Windows and doors that must be left open by night or day must be protected by some positive method of closing such as screens, screen doors, or Dutch doors. All passage ways protected by doors having extensive usage must be closed by a fluid door closer made by a reliable manufacturer. Doors of intermediate usage may be operated by spring hinges. Dutch doors are approved when they are treated to prevent rats from climbing over the top.

7. The estimator must determine whether windows are to be opened or closed. If windows must be opened, then proper screens must be installed.

8. All rat guards must be correctly placed and of sufficient size. They must provide protection for a reach of 18 inches from point guarded and for a distance of 24 inches along object being guarded. No rat guard should be placed lower than 8 feet above the ground in an alley or other place where articles may be stacked against the building.

9. Foundation walls may be protected by a barrier of solid masonry concrete continuous with concrete basement floor, or by the use of "L" -shaped exterior curtain walls.

10. Information sheets should be prepared with details of cost.

Cost of Materials: Materials for which prices must be known in order to complete the estimation of cost of a rat-proofing program are: anchors; bars, push; brick; bolts; cement mortor; closers, door; concrete, ready mix; doors, screens; doors, wire; doors, wood; fly screen cloth; glass and putty; hangers, screen; hardware cloth; hinges, butt; hinges, spring butt; hooks, safety gate; iron, angle; iron, reinforcing bars, concrete; iron, strap; irons, corner; labor, welding; lumber; machine work; plates; pull, door; rod, brass, rectangular; screws, rivets, etc.; sheet metal; spring, coil, screw door No. 3; threshold, alachrome; threshold, brass; transom, screen; transom, wood; valve, flap.

Cost estimates that must take into consideration: (1) material cost, (2) labor costs, (3) overhead, (4) profit to contractor.

Vent stoppage: The cheapest possible method of rat-proofing for older or old buildings is that of "vent-stoppage." It is not meant that this method should not be used on new buildings, but that more fundamental reconstruction should be encouraged for new buildings. Vent stoppage is the closing or protection of openings in the exterior walls of buildings, to prevent ingress or egress of rats. This method is only effective if applied to all adjoining buildings in a given area. The usual vents in buildings that require closing or protection are mainly ventilation openings, pipe and cable openings, deteriorated walls, and spaces around doors or windows that do not fit snugly.

The edges of doors should be protected against rat gnawing by 24 gauge galvanized sheet metal. Care should be taken to replace all decayed portions of doors and door facings before flashing in order to secure permanency of work. It is important that doors should be installed in open stairways and kept closed at night. Flashing front doors on a busy street is usually unnecessary, because where such doors are installed to fit snugly, rats have rarely been found to gnaw thru them.

Ventilator openings in foundations walls are often main points of entry for rats into buildings. To protect these openings properly, materials should be used which will be lasting in quality, such as perforated galvanized sheet metal of 14 gauge or heavier (galvanized after perforating), expanded metal of 18 gauge of heavier, or cast iron grills. Perforations or openings in the grill should never be larger than 1/2 inch. Many old buildings contain over-size ventilators and abandoned windows in the foundation walls. These should be partially closed with masonry and metal grills installed in the remaining openings.

To protect windows, especially those which are close to the ground, against rat entry and at the same time not reduce appreciably the amount of light passing thru them, 16 gauge galvanized wire cloth of 1/2 inch mesh should be used. The wire cloth should be installed for the entire height and width of the window.

Miscellaneous openings like those through which pipes, cables, and drains pass, and those caused by the deterioration of walls should be sealed with brick, cement, metal or concrete. Great care should be exercised in properly sealing or protecting abandoned sewers and drains leading into buildings.

In the case of buildings of wood frame construction in small towns and villages, vent stoppage is usually more expensive than for buildings constructed with masonry walls. The reason for this is that the space underneath the floor must be enclosed with a curtain wall of galvanized metal or masonry extending 24 inches below the surface of the ground, or the building must be elevated at least 18 inches above the ground surface. All other openings in wood frame buildings should be closed or protected in a manner similar to that for buildings having masonry or concrete walls.

Investigation and correction should not be forgotten in garages, chicken coops, and other outbuildings.

Storage and Removal of Refuse: It is well understood that rats will live close to where they can obtain food. Thus, adequate storage of foods must be planned in rat-proof buildings and equipment. The storage of refuse, especially garbage, must be in accordance with the following procedure in order to be effective.

1. Garbage cans should be of heavy galvanized metal, water tight, tight fitting lids, easy for user to remove, and kept closed at all times.
2. Garbage cans should be big enough to hold garbage between collections.
3. They should be so arranged as not to be overturned by dogs or other animals.
4. There should be proper collection methods, and disposal methods should not be such as to encourage rat-harborage.
5. Removal and proper storage of old lumber, boxes, rubbish heaps, trunks, piles of bricks, etc., should be done in accordance with rat control technique.
6. Garbage ordinances should be enacted and enforced.

Signs of Infestation:

Tools Needed. The following equipment should be carried by the sanitarian routinely in making

investigations for infestation:

1. An adjustable-focus flashlight.
2. A small adjustable inspection mirror for examining places difficult to see.
3. A clipboard with forms for recording information needed to plan control measures.
4. Flour or dust for tracking patches, and a straight-edge for smoothing such patches.
5. A fluorescent mercury lamp for detection of rat urine.

Information gathered on an Inspection:

1. Whether rats currently infest the building or premise.
2. Types of rat signs and the degree of infestation estimated from the rat signs.
3. Such information as will assist in planning the type of rat control to be used, such as outside openings larger than 1/2 inch, potential points of entry, harborage sites, food sources, detailed location of travel routes, etc.

Droppings. Rats usually defecate one or more times an hour. Adult rat droppings are 1/4 to 3/4 inches long. The droppings of young rats, mice, and large roaches may be confused. It is necessary to know the age of the droppings so as to determine whether the premise is currently infested. Fresh droppings are soft, moist and often glistening. Color is usually black, but may vary with food intake. Within a few days, droppings become dry and hard. Later the surface becomes dull, assuming a grayish, dusty appearance with great age, and is easily crumbled between the fingers.

Tracks. When travelling over dusty surfaces or through powdery substances, rats leave very characteristic footprints. The tracks of the 5-toed rear paws are more commonly observed than the 4-toed front paws. When moving slowly over flat surfaces, the tail may leave wavy lines. Old rats tend to drag their tails while young rats tend to carry theirs in the air. Tracks are most easily observed by directing the illumination on the tracks at an angle. In places like flour mills, there is often a heavy deposit of dust each day and any tracks found in sites exposed to settling dust will obviously be fresh. In other places, such as excavated areas under buildings where the air is still, tracks remain sharply defined for many weeks. In such places the age of tracks may be roughly approximated by pressing the fingertip lightly on the dust beside the tracks and comparing the resultant mark with the tracks for depth, sharpness of detail, and absence of dust particles. Size of tracks indicate age of rats. The tracks will indicate the places frequented. During re-inspection, the placement of dust-tracking patches will record rat activity.

Runways. Rats tend to follow the same routes when travelling inside a building or when entering from outside. Where the oily fur of the rat rubs against surfaces in its travel, marks are left which in a short time become visible. Runways should be sought along the inner sides of pipes and wires extending along or up both the exterior and interior walls of the buildings and along the surfaces of every beam. They may also be found along the sides of fire escapes and ladders leading to upper floors or roofs. Runways will lead to where they enter a building, to nests, and to feeding places. Rats will travel, when possible, inside closed spaces, and the openings where they leave these spaces show discoloration. Runways along floors, stairs, and shelves follow the walls or any narrow passageways between stored materials. Such runways are usually marked with rat droppings, and on close inspection, with urine stains. Runways not in use may show cobwebs and undisturbed settled dust. In active runs, the grease is soft and sticks to the finger when lightly touched. In abandoned runs, the grease is hard and dust coated. The fingernail will leave clear, knifelike lines when scratched across old markings.

Gnawings. Rats gnaw openings to get into buildings, through interior obstructions, and through outer covers of packages. Recently gnawed wood surfaces are fresh and light colored in appearance. The edges become darkened in a few days, and the cuttings become scattered and swept away. The extent of the damage to cases and sacks provides a good index for estimating the rat infestation of building. Mice damage should be distinguished from rat damage.

Burrows. Unlike nests, burrows are readily observed on casual inspection. They are found along the outside walls of buildings, in dirt basement floors, and around many of the outbuildings of a business, residence, or farm. Away from buildings, burrows may be found in embankments, hedgerows, fills, and under any heavy growth of brush, bushes, and the like. The tell-tale small

mounds of earth before the holes are usually first evidence noted after discovery of the burrow opening. Absence of cobwebs and debris in the hole entrance is indication of rat use.

Miscellaneous Signs. Rat odor, urine stains, live rats, dead rats, rat nests, and food stored by rats may be encountered in the course of rat infestation inspections of buildings. The presence of rat odors usually signifies many rats. The observation of live rats in day time indicates very heavy infestation. Dead rats may be due to rat poison or an epizootic. This should be determined. Dried out, unmolested carcasses indicate light infestation. New nests indicate that active breeding is taking place, a condition to expect where there are many rats. Rat nests are found where rats are least molested. The finding of rat-stored food is an indication of infestation. The significance of the caches can be measured by the quantity and age of items found.

Rat Urine Detection by Fluorescent Lamp. The detection of rat infestation is accomplished by a number of signs by the sanitarian among which are evidence of staining by rat urine. Urine stains are uncertain stains at best, but if detection could be effectively done it could serve the sanitarian well in inspection of warehouses and other places where food is stored. On some materials, these stains show clearly in normal light. On other materials they can be revealed by the fluorescent property of urine under ultra-violet light. Portable lights for this purpose may be added to the sanitarian's equipment.

Fluorescence is a term used to describe the resulting radiance of an illuminated substance when the radiant light is made up of colors which are not present in the source of illumination. No chemical change is involved in this phenomenon. It occurs wholly within the molecules.

The portable light used by the sanitarian consists of a fluorescent mercury lamp, enveloped by a red-purple glass (black glass has been used.) The light rays, when filtered through such a colored glass, give out intensified ultra-violet radiations which render the object (in this case the urine) more intensely fluorescent. The lamp is attached to a long cord which can be plugged into an electric socket and flashed on sacks, shelves, bags, and other food containers, the fluorescence giving circumstantial evidence of urine. A lamp has recently been developed which operates on a battery and has thereby eliminated the cumbersome cord attachment. This is a screening test. Confirmation must be obtained by bringing a sample of the sack, bag, or other material to the laboratory for confirmation by a chemical test for urea or by finding droppings or other physical evidence of rats.

It must be remembered that larger animal or human urine will give the same results, therefore, the sanitarian must be also acquainted with the usual appearance of the distribution pattern of rat urine under fluorescence. Rat or mouse urine appears as a small and sometimes fine spray or dribble, whereas large animal or human urine appears as large fluorescent splotches. If a bag or sack appears as a mass of fluorescences, the cause is probably due to the contents inside the container or to the material of the bag or sack itself. It is probably the urea of urine which appears fluorescent. Other common substances which have noticeable fluorescent properties are crab cartilage, quinine, glucose, oils and greases, and raw coffee beans.

Destruction of Rats:

Trapping: Trapping is a fair secondary measure, supplementing vent stoppage or other primary control measures. It helps to clear buildings of rats after their harborage has been destroyed or after their exit from the building has been closed. It will also help determine the effectiveness of the primary control measures.

Trapping is less effective where food is plentiful and especially where the food is not kept in rat proof containers. Rats are not easily fooled. They grow suspicious of traps and poisoned foods if techniques be not sufficiently varied. Trapping is more successful when many traps are used at a time than when just a few are used because it is necessary to catch as many rats as possible before they become suspicious and avoid traps. Trapping is practical in warehouses and storerooms if other more permanent measures be also used. It must be carried out systematically and persistently. It can, to a certain extent, control new comers.

Snap Trap (Guillotine or Spring Trap) is the most effective. Rats become more quickly suspicious

of cage traps. The bait used may be solid or semi-solid, such as fried bacon, fish, cheese, liver, fresh bread, doughnuts, canteloupes, tomatoes. Baits should be frequently changed. Rats like non-decomposed food. Soft bait may also be used such as rolled oats or cornmeal and butter, ground codfish and the like.

Trap setting must be carried out correctly if good results are to be obtained. Solid or semi-solid bait should be used in large chunks, and should be fastened to the trigger of the spring trap. Soft baits are smeared over the surface of the trigger or scattered over the base of the trap below the trigger. The trap is put in runways along walls, behind or between objects, or in places that afford rats complete or partial concealment. In runways, the trigger part of the trap is placed toward the wall because the rat runs close to the wall. The trap may be placed at the end of a narrow space made by setting a box close to a wall. The trap is so placed that the trigger end is close to the wall and exposed to the narrow passage while other end of the trap is hidden behind the side of the box. When rats get suspicious, cover the trap with paper or place the trap in an excavation or depression between two boards, so that the surface of the trigger is level with the floor or earth. The trap can be placed in a box or pan and covered with grain, rolled oats, cornmeal or the like. Boxes or pans with grain but without traps may be placed around first to accustom the rats to the situation, or the traps may be placed in strategic spots with bait attached but without setting the trigger for several nights.

Precautions in Trapping:

1. The trigger must be adjusted so that a slight touch will spring the trap.
2. The traps should be touched with the hands as little as possible. Pliers or tongs should be used to handle traps whenever practical.
3. All traps should be scalded or flamed at intervals to remove the odor derived form the hands.
4. Traps may be deodorized by dipping in hot melted paraffin to decrease the amount of odor that will cling to the trap by handling.

Bait Poisoning: Rat poisoning with bait has up to recently been considered a secondary method of rat control. Since 1944 when sodium fluoroacetate was discovered, commonly called "1080", bait poisoning became a primary method of rat control. It has gained this status because the new poisons have been so efficient that it made possible the destruction of whole rat populations in a relatively short period of time. It is now possible to really rid the civilized world of rats and mice with effective rat-proofing and bait poisoning. How long it will take to deliver us from the rat is a matter of how soon and how much society is willing to appropriate in money and effort to do so. "1080" is a violent human poison and has been displaced by other less toxic but efficient poisons. Warfarin and Pival, for example, have become popularly used poisons.

The following fundamentals are pertinent to the planning of a bait-poisoning program.

1. The larger the scale of operation, the more effective it will be. Poisoning in a single house is futile unless the house be well rat-proofed beforehand.
2. In urban communities the most effective results will be obtained if areas no less than an entire block be poisoned at a time, since streets serve as moderate insulation against rat migration.
3. Every effort should be made to kill the last rat.
4. In rural areas, whole farms should be baited at one time.
5. Spring, summer, and early fall appear to be the most favorable times of the year for poisoning operations.
6. Programs should be thoroughly planned and executed with official and popular support and with stipulation for a long time surveillance.
   a. The area to be poisoned should be surveyed to determine where baits are to be placed.
   b. All persons in the area should be notified of the approximate time of the poisoning operation.
   c. All food and water sources available to rats, such as uncovered garbage, food for pets, and kitchen foods, should be removed if possible 24 hours before poison is distributed.
   d. All individuals in area should be warned to keep children and pets away from poison.
   e. Dead rats should be collected and burned or buried.
   f. After the poisoning operation, rechecks should be made at monthly intervals to see

if any more rats be present, and to take blood samples in typhus areas in order to determine the trend of the disease among rats.

7. In typhus areas, DDT dusting should be carried out before poison distribution.

8. Projects may be carried out by exterminator companies, municipal crews, volunteer groups, or a combination of any of these.

9. Wherever possible, rat-proofing programs should go hand-in-hand with bait poisoning programs.

Warfarin, red squill, and Antu are cheap and generally recommended for use by the public because untrained individuals are least likely to experience difficulties in using them. Commercially prepared baits containing arsenic, phosphorus, and strychnine are best restricted to indoor protected stations to minimize accidental poisoning hazards. Barium carbonate is rarely used any more. Thallium sulphate is dangerous and should be used only by professional operators; this is also true of sodium fluoroacetate.

Warfarin ($C_{19}H_{16}O_4$) or Compound 42, or Warf-42 belongs to a class of anti-coagulants (reduces or prevents the coagulation of the blood) of which dicumarol is the most widely known. It is a stable, colorless, crystalline solid. It is odorless and tasteless; soluble in acetone and dioxane; moderately soluble in methyl, ethyl, and isopropyl alcohols; almost insoluble in water; and insoluble in benzene and cyclohexane. Chemically it is called 3-(alpha-phenyl-beta-acetylethyl)-4 hydroxy-coumarin. It produces painless death to animals by causing internal bleeding. It is slow acting, usually requiring 5 or more ingestions within a 10 day period of baits with 0.025 to 0.05% concentration of the poison, the intervals between each ingestion being not longer than 48 hours. No "bait shyness" occurs. Its toxicity varies for different species of rodents, being most effective against the Norway rat, but the black rat being 3 to 4 times more resistant. Mice are even more resistant. It is nevertheless very effective, having produced excellent control in about 15 days by the placement of 4 to 8 bait stations per block. Large amounts of bait are required, the average being 2 to 5 ounces per rat recovered. Usually 1 pound of bait is sufficient for treating individual homes, and 2 to 3 pounds for an ordinary business establishment. The cost of bait per rat is about 5 cents. This high price and delayed killing action frequently makes it advisable to employ other rodenticides such as 1080 at first for a quick reduction in rat population. Warfarin ranks with red squill from the standpoint of minimum potential hazard, but should not be placed in locations where food or feed contamination may occur or where children, pets and livestock can easily come in contact with it. Birds exhibit a high tolerance to it, but dogs have succumbed by eating 2 ounces of the bait daily for 5 days and cats on about 1/2 ounce for a similar period. Cats may also be killed by eating a poisoned rat on each of 6 to 8 days in succession. Hogs are quite susceptible to the poison but sheep are highly resistant. An adult human would probably require nearly a pound of bait during 4 consecutive days to be endangered.

Grain or cereal type baits are preferable. Coarsely ground yellow cornmeal is quite acceptable by Norway rats and is superior to white cornmeal, chow, mash, or other dry baits. Bread crumbs and meat can be used. In the South, addition of an equal amount of pecan crumbs gives better control of black rats. A satisfactory formula in terms of "weight" is: 1 part 0.5 commercial warfarin (or pival), 11 parts yellow cornmeal, 6 parts breakfast rolled oats, 1 part granulated sugar, 1 part corn, peanut, or mineral oil. The oil is employed in the formulation to reduce excessive dusting of the chemical. The keeping quality of baits is still questionable. Although degerminated cornmeal is less apt to become rancid than ordinary cornmeal, the latter is more acceptable to rodents. Care should be exercised to employ a clean product free of insects and mold. Mold may be delayed from developing by avoiding the use of water in bait materials and by placement in appropriate containers to prevent contact with dampness from the ground. Molding of baits exposed in fields may be delayed by the addition of 0.3% of paranitrophenol. The use of warfarin as a tracking poison has not been found effective. It is desirable to discolor warfarin powder and baits with a distinct warning dye. This can be done by adding 4 ounces of animal charcoal or 1/2 ounce of vegetable charcoal per pound of commercial warfarin. A lake green pigment at a 0.5% concentration provides a good warning color for corn-meal and is well accepted by rats. Warfarin can be bought by the public as a 0.5% concentrate with corn starch as the diluent. One pound of this mixed with 19 pounds of bait will provide the usually recommended concentration of 0.025%, and 1 pound to 9 pounds of bait will give 0.05% concentration which should be used when 0.025% is not effective, as for the Norway rat and mice. Water soluble forms of this rodenticide are, at present, under study. From 2 ounces to 1 pound of bait is suggested as the amount to be placed in each location. Feeding

stations should be inspected and replenished daily during the first few days of treatment and at periodic intervals thereafter. Inspections will help to determine the correct quantity to be added during visit. It is important to remember that rodents must have access to ample bait during a 5 to 14 day feeding period in order to be effective.

To prepare bait, deposit the bait material into a clean drum or can and deposit correct amount or warfarin concentrate on top of bait material. Replace cover on drum or can and shake or roll it thoroughly and long enough so that when some of the mixture is removed on a paddle or stick and smoothed out it shows no streaks of color. If streaks exist continue to mix. When ready, pour mixture into clean metal or crockery containers and distribute them to feeding stations. Pre-baiting is not necessary. In many instances bait boxes are necessary to protect poison from children, pets, stock, or to prevent possible contamination of foods and feed products. Such boxes are constructed of wood or metal. The simplest bait protector is a five foot board, eight inches wide, which can be nailed at an angle against the wall. Feed cats and dogs well while heavy baiting is being carried on so they will not be tempted to eat bait or dead rats. Bait is ordinarily placed in, under, or near chicken houses, machine sheds having dirt floors, near grain storage rooms or corn cribs, and near watering spots. It no watering places be around, place a can of water near the bait. One or two placements are made at every point of great activity. Too many placements are better than not enough. Watch for rat tracks by sifting white flour on ground or floor around the placed bait, or wherever rats are suspected of traveling. If there be no tracks for two or three nights, change location of bait station. Rats may not touch bait for a few days if other attractive feed be amply available. It may therefore be necessary to make bait more attractive by adding a small amount of corn oil or other vegetable oil (1%) or sugar (2%). Such bait mixture is almost always eaten by rats. Sugar should not be used in warm, humid weather unless the baits be inspected regularly for mold. Keep some of the bait available in permanent stations to catch stragglers. Normally, most poisoned rats will not be seen since they apparently die in burrows under the ground because they become too weak to climb. There is seldom an odor problem.

If a cat or a dog be found eating a warfarin killed rat, feed it fresh milk. If a human being has been known to have eaten the concentrate or bait, call a physician. His treatment will include transfusion with whole blood and intravenous and oral administration of Vitamin K. Normally, there is no harm to humans on external contact with warfarin except possibly of an allergic nature.

Pival ($C_{14}H_{14}O_3$), also known as tertiary butyl valone, compound 333, pivalyl and indandione, is a warfarin-like material and is a fluffy, yellow powder with a mildly moldy, acrid odor suggestive of marigolds or tobacco. The sodium salt is a grainy powder with only a trace of indefinable odor; it is soluble in water up to 0.1 mg. per ml. but precipitates out easily. To eliminate this drawback, Versene (regular) can be added to the water to make a 0.1% solution from which the Pival will not precipitate. The keto form is essentially insoluble in water, but is soluble in organic solvents.

Contrary to original indications, it appears that this poison is not effective in killing the ectoparasites that feed on the rodents at the same time as it kills the rodents. This poison is available in 0.5% commercial form. The same formula is used for pival as for the preparation of warfarin bait. Pival appears to be somewhat inferior to warfarin in solid baits for control of the Norway rat. But pival poisoned water (0.006% acid equivalent) with 5% sugar is slightly more efficient than warfarin for this species.

The possibility of human poisoning must be kept in mind. This is unlikely to occur except from gross carelessness or from suicidal intent. The hemorrhagic signs should be relieved by transfusions and Vitamin K therapy. Large single doses may cause death by pulmonary and visceral congestion without hemorrhagic signs. No guide to treatment is available for this very acute, non-hemorrhagic type of poisoning.

Sodium fluoroacetate or 1080. Even though the properties of warfarin are such as to greatly replace 1080 in routine usage, the latter may continue to be important in instances when emergency rapid reduction of rat population is desired, and where wild rodent life is in need of control. The efficiency of this poison consists in that it is extremely toxic to rodents, that its taste and odor do not repel rodents, and that rats do not seem to develop any significant tolerance to it. Even better, it appears that rats prefer water poisoned with 1080 than fresh water. It is so widely toxic

that it will kill ants, cockroaches, cats, dogs and man as well. It will even kill cats and dogs which eat rodents poisoned by 1080. That is why it must be used with great precaution and by trained personnel only. Observations indicate that field rodent control practices may be dangerous to sheep, but not to cattle. Pigs and goats are subject to poisoning by 1080. Its use against such predators as prairie dogs, ground squirrels, and chipmunks is still in the experimental stage.

1080 is a white fluffy powder similar in appearance to flour or baking powder and is very soluble in water. To human taste it is mildly salty-sour which is neither distinctive nor objectionable. Some lots have a slight acetate odor, but this is not a consistent characteristic. Because of its lack of warning characteristics and high toxicity, it should be handled with more than usual caution. Persons who have to handle the raw poison should use masks while opening bottles or cans, and during all weighing or measuring operations. It kills by its action on the central nervous system and the heart. It kills rats so quickly that they may be found dead a few feet away from the poison

If there be any cuts or open wounds in the hands, rubber gloves should be worn. Smoking or eating should be avoided while handling the poison to prevent it from reaching the mouth. Persons working with this poison should be careful to avoid carrying the poisonous dust home on clothing or shoes lest pets be endangered. There is no antidote for 1080. When put out for control of rats and mice, it is recommended that it be used indoors only. This poison does not appear to deteriorate when mixed with bait or water. It does not corrode metal and is insoluble in oils. When exposed to air it quickly takes up moisture and becomes sticky. It is non-toxic on the skin and non-irritating to unbroken skin.

Its toxicity to man as compared with other rodenticides may be expressed in the following manner: If it takes a certain amount of 1080 to kill a man, it would take about 1/5 as much strychnine to do the same, about 1/4 to 3 times as much arsenic, about 4 times as much thallium sulfate, about 4 times as much zinc phosphide, about 20 times as much antu, and over 100 times as much barium carbonate.

Preparation for use. For use in rat and mice control, 12 grains of 1080 to a gallon of water is recommended. Due to the great toxicity of this poison, its use in solid baits for rat control is not recommended, at least, until further study and experience indicate the contrary. At present, the use of only "poisoned water" is recommended for rat control. The use of this poison in the control of field rodents such as ground squirrels and prairie dogs is a specialized business. The methods of preparation and use of baits for the latter purpose may be obtained by writing to the Fish and Wildlife Service of the Department of Interior.

All mixing equipment should be labelled plainly and washed thoroughly after using. The washing of equipment and containers should be accomplished by flushing with large quantities of water and emptying into a sanitary sewer. Hands should be washed thoroughly after mixing or distributing the poison.

It is recommended that the powder be put up in 6 gram lots in individual glass containers so when workers go into establishments, preparations of the poison can easily be made by adding 1 jar to a 1/2 gallon of water. All jars should be labelled. In preparing the solution, 20 drops of black india ink may be added to each 1/2 gallon of water in order to give it a dirty appearance to distinguish it from plain water. When in use all materials and containers should be kept locked up.

Schedule for Poisoning Operation: The use of 1080 on any premise must first be discussed and explained to the occupant and his permission obtained. Use of 1080 should be preceded by widespread warnings to owners of pets that such animals should be kept away from where the poison could be reached or where sick or dead rats could be found and eaten. The poison should not be used in dwellings of residential areas. Where rat-proofing programs are in progress, a 1080 poisoning project should be done immediately before or after the completion of rat-proofing of establishments. The poisoned water is distributed in 1/2 fluid ounce quantities in 3/4 ounce capacity flat-type souffle cups or small heavy glass caster cups. To avoid spilling the poisoned water while filling these small containers, a rubber bulb with a nozzle should be used. The empty cups should be placed in the final location first, then filled. The cups should always be placed on the floor, 4 to 6 inches from the main passage of rat runways rather than directly in the runways where the containers may be tipped over by the rats. Cups should not be filled more than two thirds.

The containers should not be placed where workers' or customers' movements may disturb them, nor where children or pets have access to them during poisoning periods, nor on merchandise, spilled grain, sugar or other food. Every container should be protected by a specially made bait station such as a 12" x 12" piece of metal or wood securely anchored and not more than 3 inches from the floor.

The exact number placed in each room should be recorded and recovered at end of operation. Paper containers should be burned or buried 3 feet deep. These should not be put into the garbage or rubbish and should not be re-used. Other containers should be thoroughly cleaned and the contents flushed into a sanitary sewer before re-using. Pets should be kept away from poisoned areas for at least 5 days. Search should be made for dead rats every day. These should be burned or buried.

If good control of rats be not obtained from the use of 1080 in recommended concentrations, the fault is not with the poison but in the method employed.

The ability to destroy rats quickly and in large numbers has posed a problem in the control of typhus, since the infected flea will leave the dead rat in search of warm blood meals. When a number of rats are killed in a short time, swarms of fleas may infest the area and be more prone to seek their blood meals from humans, and thus transmit typhus fever. To control such circumstances, the places where poisoning is to be carried out are sprayed with DDT beforehand to kill as many fleas as possible on the living rat. Then when the fleas leave the dead rats, they will be exposed to the DDT. In this way the increased number of typhus cases contracted during a rat poisoning campaign is controlled.

Treatment in Cases of Accidental Poisoning. Treatment is limited to the use of emetics, and the poison must be eliminated within a few minutes if the absorption of dangerous quantities is to be prevented. Make the patient vomit by tickling the throat with the finger, or give 1/2 teaspoonful of powdered mustard in a cup of warm water. Give a dose of Epsom salts as a purge. Call a physician at once.

Compound 1080 affects the myocardium and central nervous system. In man, the effect on the heart is the primary cause of death. Pulsus alternans appears first, followed by premature systoles and ventricular fibrillation. The central nervous system reaction is shown by epileptiform convulsions.

Antu Poisoning. Alpha-naphthyl-thiourea is about 1/20 as potent as 1080, but has been successfully used in rat control campaigns in recent years. This poison is especially effective against the brown rat, less for the black rat and house mice. It does not poison chickens, pigeons, rabbits, guinea pigs or squirrels. It can kill dogs and cats but these animals usually vomit the material before the poison is absorbed. As far as is known, it is probably nontoxic to man except in large amounts.

It is a bluish-gray powder, highly insoluble, stable to heat, deteriorates very little has no perceptible odor and only a slight bitter taste. It kills through the stomach not through contact with the skin. It acts on the lungs chiefly. Within a few hours after poisoning, the lungs and thoracic cavity become filled with fluid and the rat literally drowns in its fluid. Rats die within 10 to 24 hours. If the first dose does not kill them they may develop a tolerance which may last 30 days. Equal amounts of tartar emetic and Antu in bait mixtures will protect other animals.

Methods of Preparation and Use. These methods depend on how the bait is to be used:

1. Ground Baits. Thoroughly mix 2 or 3 parts of Antu with 100 parts of finely ground grain, preferably a high grade yellow corn. Distribute in small shallow piles.
2. Dusted Baits. Place freshly ground yellow corn or other grains in small piles on floor or earth and smooth out to a flat thin layer about 1/4 inch thick. Dust the grain and surrounding areas for 6 inches with Antu, using a small spray gun, duster, or shaker. Use diced apple, sweet potatoes, tomatoes, cantaloupes, watermelons, ground meat, the white and yolk of eggs, and fish or chicken heads in the same manner. Dust Antu on fresh ears of corn, the kernels of which have been slit by running a sharp knife lengthwise along the cob. Cut the cob into 1 inch sections and distribute.

3. Dusting Floors and Runways. Spread a 50% mixture of Antu and flour over ground in areas which rats frequent, especially along runways and near openings. Good results have been obtained with a 20% mixture of talc or flour.

4. Pumping in Burrow. Pump Antu powder or flour-Antu mixture into openings of rat burrows with foot or hand duster until floor of burrow is coated.

5. Dusted on or Mixed with Water. Use small cups or dishes. Dust Antu on water until it forms a thin film on surface, or put 1 to 2 parts of Antu with 100 parts of water in a bottle, shake well, and pour into a shallow dish. After being shaken up with water, the powder tends to settle within a few hours so that repeated shaking or stirring may be necessary.

For best results, use several methods at the same time. Try to provide an excess of bait for all suspected rats, but do not throw bait around carelessly. Make the rats first poisoned meal its last meal. Use those baits which are seasonable and most attractive. Yellow corn is the best. Coloring baits with an insoluble pigment (such as duPont chrome green G-550-D) will reduce the possibility of poisoned baits being mistaken for food.

The fundamentals previously outlined for rat bait-poisoning programs apply here. A city block can be treated with poisoned bait in several hours by 2 to 4 men. With proper technique at least 90% of rats can be destroyed in a single operation. When yellow corn or equally attractive baits are not available, it may be desirable to pre-bait the area with unpoisoned baits for several days to make certain that the rats will eat the bait freely. If typhus fever be prevalent in area, dusting with DDT to kill infected fleas should be done before poisoning operation. Place poisoned baits near feeding places, especially garbage pails and food storage places, or in sheltered spots where rats can eat without being disturbed, also near sources of water for rats, near burrow entrances, harborage sites and along runways. These baits, particularly poisoned water should be distributed in the late afternoon if possible. Use only grain baits in places which dogs and cats frequent. Allow bait to remain in place for 2 nights.

When the poisoning operation is over, remove baits and dispose of them in a place inaccesible to pets Close burrows. If any rats remain, the holes will be reopened within a few days. Sweep up droppings, and check for fresh droppings. Look for dead rats for several days following poisoning. In cold weather, few rats die on the surface. Dust flour on runways to show up freshtracks, have everyone watch for rats and report to the sanitarian. Recheck at monthly intervals. Keep after them to the last rat. Repeat antu treatment once a year if necessary. Institute sanitary measures insofar as possible to eliminate rat harborage and sources of food for rats.

Treatment in Case of Accidental Poisoning of Human or Pet. Call a doctor or veterinarian. Induce vomiting. Treat for shock. Keep warm. Give oxygen inhalation if available. Poisoning with Antu causes drop in body temperature, increased blood sugar, dyspnea, pulmonary edema and pleural effusion. These may develop within 1 to 3 hours.

Red Squill. This poison, although not as efficient as some others, is nevertheless least toxic to humans and pets that we have. It can be readily used in residential areas without fear of poisoning the unintended. Besides being a poison it is an emetic. Humans and other animals readily vomit it out. Rats and mice are unable to vomit and thereby succumb to it.

Mixtures of red quill bait depend entirely on the degree of toxicity of the squill used. But there is no need any longer to use non-standardized material. Red squill powder can be obtained in standardized form to contain a guaranteed strength of at least "500 milligrams per kilogram." It is very effective in this strength when the bait is made up to contain 1.6 ounces of red squill powder to a pound of bait (or 10%.) When using the above strength, the following formula by weight is effective:

1 part red squill,
2 parts cornmeal, flour or oatmeal or a mixture of these,
7 parts fresh lean meat, fish or shrimp.

Another formulation by weight is:

1 part red squill
5 parts fish
4 parts cornmeal
1/3 part oil

It is advisable to distribute two kinds of bait. Meat and fish are most desirable. Bait prepared in the form of torpedoes renders most effective results. The torpedoes are made by placing about 1/2 teaspoonful of bait (about 1/2 ounce) in a paper napkin and twisting the ends. Colored napkins may be used to differentiate between the kinds of bait used. The effectiveness of torpedoeslies in the fact that they are small enough to be carried into rat harborage, resulting perhaps in destruction of an entire nest.

The best kind of meat is fresh raw hamburger and the cheapest bait is canned fish. Powdered red squill should be thoroughly mixed into each food, keeping the different kinds of bait separate. A little water may be added to moisten baits to aid in mixing.

It is advisable, before poisoning, to pre-bait with small amounts of unpoisoned food to see which the rats prefer. If torpedoes are not made from the bait, just distribute it by teaspoonful lumps on the floor or ground along walls, runways and places where rats usually feed or frequent.

Enough bait should be used at one time for all rats on the premises. A thorough poisoning on one night is better than the frequent use of small amounts of poison. It takes 4 hours to 4 days, usually less than one day, for red squill to kill rats. Premises should be searched for 3 or 4 days after poisoning for dead rats.

Through the experience of the rat poisoning work in Georgia, a method of estimating the cost of such projects for towns of less than 10,000 population, has been worked out. A project for the business district of a town is estimated to utilize .05 pound of bait per person living in business districts, while a project for city-wide extermination of rats would utilize .25 pound of bait per person in the population. In farming areas .5 pound of bait per person is generally used, while for an individual farm 2.5 pounds of bait per person living on the farm are required.

A supervisor should be provided in towns of 2,000 population or over. Crews composed of a foreman and four laborers are recommended. One crew is needed in a town of 1,000 population and up to four crews for one of 10,000 population.

Where labor is not available in the amount indicated, the bait for the residential properties is not put out by baiting squads but instead it is delivered in paper bags to a responsible person at each home with instructions for putting out the bait. Some local person should act as city leader to release publicity, purchase materials, obtain the help, and assist the supervisor during the campaign.

The services of the U. S. Bureau of Biological Survey, Department of Interior are available to cities and towns in conducting cooperative rat-poisoning campaigns by giving supervisory assistance insofar as funds permit and technical information without cost to the local agency. The local cooperating agency, such as town or county, will provide materials, equipment, labor, and local supervision.

Barium Carbonate: This is a heavy, odorless, tasteless powder. It is poisonous for rats in small doses of about 2 grains, while 15 grains will kill chickens, and 100 grains will kill dogs. It is relatively non-poisonous for man except when consumed in large doses. It produces an intense thirst and tends to cause the poisoned rats to leave the buildings in which they live to search for water. Consequently many rats poisoned with barium carbonate will die in open places from which the carcasses can be readily removed.

Barium carbonate should be used in proportions of one part by weight of poison to two parts of bait, and is distributed in the same manner as red squill.

Arsenic: This is a powdered arsenious oxide, tasteless, odorless, and is a most effective rat poison, especially if it be finely pulverized and gritless, but it is also highly toxic to other animals and man. Because it is tasteless and odorless and at the same time toxic to man and animals, its use as a rat poison is extremely dangerous.

Phosphorus: This is an active ingredient in many commercial rat poisons. As a rat poison, it

is attended by considerable danger of accidental poisoning of man and domestic animals. Although it is a luminous material and has a characteristic taste and odor, it is not repellent to rats, but to some extent is repellent to other animals. It is, however, dangerous for general use as a rat poison. A product of phosphorus, zinc phosphide, has come into favor among the phosphorus rodenticides. It is highly toxic and dangerous for general use. It is effective in baits containing 1 to 2% of this poison. If 3 parts of tartar emetic be used with every 8 parts zinc phosphide in baits, other animals will be protected. Baits may be made by dusting fresh fruit, vegetables, nut meats, or mixing with chicken scratch grain in proportion of 1 ounce poison to 10 to 20 pounds of bait.

Strychnine: This is highly poisonous to rats, other animals and man. It has a bitter taste and therefore repellent to rats unless the taste can be disguised by bait. It kills rapidly and tends to cause rats to die within the walls in inaccessible parts of a building.

Thallium Sulphate: This is widely used as a rat poison. Its action is similar to that of arsenic. It is tasteless and odorless and has the same advantages and disadvantages as arsenic. It is useful in baits containing about 2% of the poison. It is an effective mouse poison.

House Mice Baits: The house mice have no aversion to thallium sulphate but dislike squill. The field mice do not mind the taste of squill and are killed by it faster and in higher percentage than the house mice.

Mouse baits may be of two kinds, i. e., stable baits and fresh baits. The former is used where the bait will remain in place for longer periods; the latter is for immediate short time use.

Some stable baits:

1. Mix 1/8 ounce of powdered strychnine alkaloid with an equal quantity of baking soda and stir thoroughly in a quart of rolled oats or cornmeal.
2. Mix 1 tablespoonful of gloss starch in 1/4 teacupful of cold water and stir into 3/4 pint of boiling water to make a thin paste. Mix 1 ounce of powdered strychnine alkaloid with 1 ounce of baking soda and stir into the starch to make a smooth creamy mass free of lumps. Into this, stir 1/2 pint of heavy corn syrup and 1 tablespoonful of glycerin or petrolatum. Apply this to 10 pounds of milo maize or canary seed and mix thoroughly to coat each kernel. Spread on paper to dry.

Some fresh baits:

1. Dice apples or sweet potatoes in 1/2 inch cubes. Dust 20 ounces of either bait material, while stirring gently, with 1/8 ounce of powdered strychnine alkaloid. Other poisons such as powdered zinc phosphide may be used in same proportion and manner.
2. If there be no household pets (dogs or cats) to be endangered, hamburger or a mixture of 2 parts ground bacon and 6 parts of a blend of ground dried bread crumbs and cake crumbs may be used as bait material. One ounce of zinc phosphide, or 2 ounces of arsenic trioxide, may be mixed with 10 pounds of one of these bait materials.

All care should be taken concerning these baits that are usually taken to prevent poison hazards to children and pets.

Warfarin: Mice can be controlled with warfarin by the same exposure techniques as employed for rats. Due to the fact that they are smaller and more frequent feeders, it is better to have a larger number of bait placements in their feeding areas, and tablespoonful quantities of bait are generally adequate.

Rodent Repellents: Study of rodent repellents is just beginning. Recently, a material known as actidione, a by-product in the manufacture of streptomycin has been found to be a good rodent repellent. It is very expensive and toxic. Continued study will bring to light better, cheaper and less toxic material.

Fumigants: The development of effective raticides has to a large extent outmoded the use of fumigants for buildings, but fumigants are still the most effective manner of ridding ships of rats. Nevertheless, the use of 1080 or similarly used substances may yet displace fumigants even from water craft. Whereas hydrocyanic acid usually gives at least 99% rat destruction in boats, 1080 has been found to give only around 85%. The desirable features of the use of 1080 for ships are:

1. Ships crew may remain aboard; 2. Operation does not interfere with the routine work on boat; 3. It is easy to recover rats; 4. Can be applied to open decks, life boats, etc.; 5. Requires less men for the control work.

The less desirable features are: 1. Only a partial kill is obtained the first day (this deficiency may be due to the method employed rather than its potential applicability to boats); 2. Aqueous solutions may freeze at low temperatures that are sometimes encountered.

Hydrocyanic Acid Gas: This is extremely toxic to all animal life and is the cheapest and most effective fumigant for rat destruction. It diffuses quickly to all accesible spaces, does not injure textile, foodstuffs, or paints, although it may tarnish highly polished metal surfaces. It is fatal to man in small quantities.

Two ounces per 1000 cubic feet of space is the quantity to be used for all forms of the acid. Two hours exposure for empty rooms and about 4 hours for rooms containing materials will usually destroy all rats.

Hydrocyanic acid may be employed in the form of HCN discoids, calcium cyanide, liquid hydrocyanic acid, or liquid modified by addition of a "warning gas" compound. HCN discoids and impregnated earthy materials are the most practical solid forms to use. The liquid form is more dangerous. The earthy substance impregnated with hydrocyanic acid when exposed to the air gives off the gas, leaving the non-toxic material. It contains 5% chloropicrin or other "warning gas." It is applied by punching holes in the can in which it is packed, and the desired amount is sprinkled on the floor at the rate of about two ounces for every 1000 cubic feet of space.

HCN discoids are discs of wood pulp which have absorbed definite quantities of hydrocyanic acid. They are available in sealed cans. When exposed to the air, the hydrocyanic acid is given off and the non-toxic discoid remains. Enough discoids are distributed on the floor so that two ounces of hydrocyanic acid is released for each 1000 cubic feet of space. Exposure should be 2 to 4 hours.

Liquid hydrocyanic acid: The boiling point of this liquid is 74 degrees F. It is vary volatile in warm dry air. It is packed in steel cylinders and is released from the cylinder as a spray which volatilizes at once. The pressure in the cylinder is provided by an air pump operated by a motor. "Warning gas" used is 20% cyanogen chloride or 5% chloropicrin which cause lacrimation.

Hydrocyanic acid may be generated by mixing sodium cyanide with an acid. Cyanogen chloride may also be generated by adding sodium chlorate. The ingredients necessary to fumigate 1000 feet of space are:

Hydrochloric acid	17 ounces
Water	17 ounces
Sodium Chlorate	3 ounces
Talc	2 ounces
Sodium cyanide	4 ounces

Calcium Cyanide: This a finely divided powder which absorbs moisture when exposed to air, and releases hydrocyanic acid as a result. It is used by scattering on floor. The disadvantage of this material is the difficulty in estimating the quantity of gas that will be given off, and the fact that its residue is poisonous.

Safety measures in using hydrocyanic acid:

1. "Warning gas" should be used.
2. Gas masks should be available and workers trained to use them.
3. It should be made certain that the space to be fumigated is void of animals and people.
4. Care should be taken that the space to be fumigated is tightly sealed.
5. When the space is opened at end of fumigation period, no one should enter till the lacrimator has disappeared.
6. Foods exposed to the gas should not be used until 24 hours have elapsed after exposure.
7. Workers must be well trained.

Sulphur Dioxide: This is less efficient and has a lower penetrating power than hydrocyanic acid. But it is also much less dangerous to man. The use of this poison is waning, but it is nevertheless a constant reminder that fumigants still less toxic to man and more toxic and efficient as a rodenticide should continue to be sought.

Calcium cyanide dust: This powder is forced into burrows by means of a small dusting pump equipped with a fexible hose outlet. This is not to be used in buildings. All apertures of fumigated space should be closed. After handling, the hands and objects that might have come in contact with the poisonous powder should be decontaminated. It must be remembered that all handling of this powder should be done out of doors.

Carbon Disulphide: This material should be used for burrows in solid earth. A piece of cotton or ball of waste is saturated with about an ounce of carbon disulphide (CS_2) and packed into burrow with a stick. All apertures should be closed. This is more effective in damp earth or during wet weather.

Carbon Monoxide: This can be used in dump burrows. It can be obtained from the exhaust of an automobile in adequate quantities by running the engine at a moderate speed. By means of a flexible rubber hose the gas can be directed into the burrow. For an average burrow, 10 minutes of engine running is efficient. All apertures to the burrow should be sealed.

Methyl Bromide: This is an effective rodenticide for use in burrows. It is non-inflammable and is effective in wet or dry soil at various temperatures. However, because it is odorless and colorless, apt to cause burns and dermatitis by careless handling, and rather high in price, this fumigant is not recommended generally.

Dead Rat Odor Control

Relief from odors may be obtained by odor masking agents which may be applied by lamp type wicks, saturated cotton wads, or mist sprayer. These agents are:

a. Isobornyl acetate - manufactured by Dupont Chemical Co.
b. Neutroleum alpha - manufactured by Tutzche Bros., N. Y.
c. Methyl salicylate - 4 teaspoonsful in a quart of water.
d. Oil of wintergreen - 1 tablespoonful in a quart of water.

Murine Typhus and Plague:

Murine typhus and plague are transmitted from rodent to rodent by ectoparasites of which the flea is the most important. Common rats and one species of the field mouse have been found naturally infected with murine typhus although many rodents and other animals have been found susceptible by laboratory experiments. Besides the rat, plague has been found naturally in rabbits and a number of wild rodents such as the ground squirrel, red squirrel, flying squirrel, western chipmunk, prairie dog, marmot, western pocket gopher, kangaroo rat, white-footed mouse, wood rat, and meadow mouse. The rat is the most important animal in the United States that serves as reservoir for plague and typhus insofar as this reservoir relates to human beings. The most important species of rats so involved are the brown or Norwegian rat and the black rat. Of less importance is the roof or Alexandrine rat and white-bellied rat.

The most important natural vector of plague from rat to man is the flea, Xenopsylla cheopis. This is apparently also true for murine typhus since all indications point in this direction and the weight of empirical evidence is overwhelming. Yet the natural vector of endemic typhus to man is not definitely known. Experimental transmission to man has apparently not been accomplished with any species of rodent ectoparasites. Because the same rats and apparently the same ectoparasites are responsible for the transmission of both these diseases, the methods of control are also generally the same. It must, however, be remembered that the flea, Pulex irritans, may transmit plague between rodent, man, and swine, and that the flea, Diamanus montanus, transmits the disease among ground squirrels. It must also be remembered that besides the flea, the rat louse and mite have been found infected with typhus and probably also serve as vectors to man. In a recent study, it was estimated that 10% of the ectoparasites on rats are mites and 6% are lice. One of the differences in control measures, at least for the present, between plague and typhus is that plague is found naturally among wild rodents (this is known as sylvatic plague) and that this condition has as yet not been found for typhus.

The bacillus which causes plague, Pasteurella pestis, is transmitted to humans by the bite of the infected flea. This bacillus grows very rapidly in the stomach and esophagus of the flea. After several days, the growth plugs the esophagus so that during the act of biting and sucking the germs are forced into the bite wound and produce plague infection. In those fleas where blockage does not occur, the transmission may be mechanical, and sometimes the transmission may be caused by infected flea feces being rubbed into the bite wound. As has been pointed out, the method of transmission of typhus from rodent to man is not experimentally established. What is known, is that endemic typhus in the United States is primarily a summer and autumn disease; that the rat flea, Xenopsylla cheopis, and the rat mite, Laelaps hawaiiensis, exhibit similar warm weather maxima; and that effective rat and ectoparasite control will result in a similar control of typhus fever in man. The possibility of other rat ectoparasites besides the flea being important in typhus transmission should not be overlooked. Another correlating fact is that there is a growing indication that the percent of typhus infected rats and human cases are both greater in slum areas than in good residential areas.

Indices. In order to have a method of measuring the critical points at which possible development and spread of plague or typhus among humans become potentially dangerous, various indices have been devised. Some of these indices will be described in order of importance as follows:

1. The "mean" refers to the mean number of particular species of ectoparasites per rat. For example, the X. cheopis index is the ratio of the number of rats to the number of X. cheopis fleas found infesting the rats.
2. The "infestation rate" refers to the proportion of rats that are infested.
3. The "rat yield per premise," is the average number of rats found per premise in a particular area.
4. The "mean number of female X. cheopis per rat" and the "number of female X. cheopis per infested rat" are variations of the first index described above.
5. The "rat flea index" refers to the ratio of the number of rats to the number of fleas found infesting the rats.

All indices proposed to date possess theoretical limitations largely related to the fact that ectoparasites apparently are not distributed at random among available hosts, but tend to occur in groups or to be "contagiously" distributed. The term "contagiousness" in this connection refers to the fact that this type of frequency distribution will be given by an event which, having once occurred, has by virtue of this occurrence an increased probability of recurrence just as one case of a communicable disease in a community increases the mathematical expectation of a second case occurring in the same community. Similarly, one interpretation of the contagious distribution of ectoparasites would be that there is less chance of a non-infested rat becoming infested than there is of an infested rat acquiring additional ectoparasites.

In making ectoparasite counts, only live hosts should be considered since the parasites leave the dead body of the host as it gets cool.

Epidemiological studies have revealed various pertinent items of information which could be useful to the sanitarian. Some of these are:

1. Endemic typhus in the United States show a greater incidence in towns of 2500-5000 population than in larger urban or in rural areas.
2. Negroes seem to be less susceptible to typhus fever than whites.
3. DDT dusting for rat ectoparasite destruction, if adequately performed, will give an effective reduction in the ectoparasite for a 3 month period and a corresponding reduction in typhus among rats.
4. Destruction of large numbers of rats in a short period of time may raise the number of ectoparasites on the remaining rats, thereby increasing the potential hazard of typhus spread for an interval immediately following such rat destruction. For this reason DDT dusting prior to eradication activities is indicated.
5. Food handling establishments appear to be the most important foci for spread of typhus.
6. Plague epizootic intensity among rats appears to depend, in a measure, on the size of the X. cheopis population in the area, and the extent of epidemics among humans appears to depend upon the intensity of the epizootic.
7. Even though endemic typhus be primarily a summer and autumn disease, good control

requires year-round activity and watchfulness.

8. Predatory birds such as eagles and owls which feed on freshly dead infected rodents may play a part in the spread of sylvatic plague by being incidental hosts of rodent fleas and by ejecting infected undigestible materials in their excreta.

9. Urban endemic typhus and plague appear to be greater potential dangers where the Norwegian species of rat is found.

Collection of Ectoparasites. Ectoparasites are collected for making counts for identification, or for inoculation. Live trapped rats are used for these operations. Live animals are delivered to the laboratory in muslin cloth bags, one animal to each bag, and then killed by crushing their necks with heavy forceps or by the administration of ether or chloroform. It has been suggested that when animal inoculation is planned in order to determine the presence of endemic or epidemic disease, hydrocyanic acid be used to kill rats, since this has little or no bactericidal action.

Rats are chloroformed in the unopened bags over glass or white enamal containers in order that ectoparasites leaving the body during the procedure may be seen and recovered.

When the rats are caught in steel traps and killed at place of capture, the bodies and containers are brought to the laboratory where they are subjected to a gaseous insecticide and the parasites recovered. The inner surface of containers should be carefully searched for parasites which may have left the body.

When live rats are killed by forceps, the bodies should be promptly suspended by the tail over a large white enamel pan containing water so that the rats nose barely clears the water level. Within 2 hours a large part of the infesting fleas will leave the cooling body and jump into the water from which they are easily recovered. The remaining fleas may be dislodged by combing the suspended body against the direction of the hair. The ectoparasites are placed in vials containing sterile normal saline solution when they are to be used for inoculation. When they are to be classified only they are preserved in vials containing 70% alcohol. The vials are identified by number indicating the rat and the district where caught.

Blood samples are taken for the purpose of performing the Weil-Felix agglutination test or the complement-fixation test in order to determine whether the animal was typhus infected. A positive Weil-Felix test apparently indicates a recent infection since the reaction in rats, experimentally infected, disappears between the 14th and 20th day following inoculation. The complement-fixation test appears to remain positive at least 6 months following infection, and has been reported to persist for many years. Tests are used to indicate the prevalence of typhus among rats in order to correlate the rat incidence with that of human cases.

Rodent Control Ordinance

The Communicable Disease Center, United States Public Health Service recommends, in its manual on "Rat-Borne Disease Prevention and Control," the following Rodent Control Ordinance. This ordinance has already been adopted by many towns and cities in the United States.

An ordinance to provide for the protection of the public health by controlling or preventing the spread of rat-borne diseases and infections by the elimination of insanitary conditions associated with such diseases, by extermination of rats, and by ratproofing of structures and maintenance thereof in a ratproofed condition.

BE IT ORDAINED BY_____ OF THE CITY OF_____

SECTION (1).

That for the purposes of this ordinance the following definitions shall apply:

(A) The term "business buildings" shall mean any structure, whether public or private that is adapted for occupancy for transaction of business, for rendering of professional service, for amusement, for the display, sale or storage of goods, wares, or merchandise, or for the performance of work or labor, including hotels, apartment buildings, tenament houses, rooming houses, office buildings, public buildings, stores, theatres, markets, restaurants, grain elevators, abattoirs, warehouses, workshops, factories, and all outhouses, sheds, barns, and other structures on premises used for business purposes.

(B) The term "ratproofing" as used herein applies to a form of construction to prevent the ingress of rats into business buildings from the exterior, or from one business building or establishment to another. It consists essentially of treatment with material impervious to rat gnawing, all actual or potential openings in exterior walls, ground or first floors, basements, roofs and foundations, that may be reached by climbing or by burrowing.

(C) The term "rat harborage" shall mean any condition which provides shelter or protection for rats, thus favoring their multiplication and continued existence in, under, or outside of any structure.

(D) The term "rat eradication" means the elimination or extermination of rats within buildings by any or all of the accepted measures, such as: poisoning, fumigation, trapping, and clubbing.

(E) The term "Health Officer" as used herein means the Superintendent, Commissioner, or Director of Health or any duly authorized representative.

(F) The term "owner" shall mean the actual owner, agent, or custodian of the business building, whether individual, partnership, or corporation. The lessee shall be construed as the "owner" for the purpose of this ordinance when business building agreements hold the less responsible for maintenance and repairs.

(G) The term "occupant" as used herein shall mean the individual, partnership, or corporation that uses or occupies any business building or part or fraction thereof, whether the actual owner, agent, or custodian shall have the responsibility as occupant.

SECTION (2).
That it is hereby ordained and required that all business buildings in the City of _____ shall be ratproofed, freed of rats, and maintained in a ratproof and rat-free condition to the satisfaction of the Health Officer.

SECTION (3).
That upon receipt of written notice and/or order from the Health Officer the owner of any business building specified therein shall take immediate measures for ratproofing the building, and that unless said work and improvements have been completed by the owner in the time specified in the written notice, in no event to be less than fifteen (15) days, or within the time to which a written extension may have been granted by the Health Officer, then the owner shall be deemed guilty of an offense under the provisions of this ordinance.

SECTION (4).
That whenever the Health Officer notifies the occupant or occupants of a business building in writing that there is evidence of rat infestation of the building, said occupant or occupants shall immediately institute rat-eradication measures and shall continuously maintain such measures in a satisfactory manner until the premises is declared by the Health Officer to be free of rat infestation. Unless said measures are undertaken within five (5) days after receipt of notice, it shall be construed as a violation of the provisions of this ordinance and occupant shall be held responsible therefor.

SECTION (5).
That the owners of all ratproofed business buildings are required to maintain the premises in a ratproof condition and to repair all breaks or leaks that may occur in the ratproofing without a specific order of the Health Officer.

SECTION (6).
That from and after passage of this ordinance the Health Officer is empowered to make unannounced inspections of the interior and exterior of business buildings to determine full compliance with this ordinance, and the Health Officer shall make periodic inspections at intervals of not more than forty-five (45) days of all ratproofed buildings to determine evidence of rat infestation and the existence of new breaks or leaks in their ratproofing and, when any evidence is found indicating the presence of rats or openings through which rats may again enter business buildings

the Health Officer shall serve the owners or occupants with notice and/or orders to abate the conditions found.

SECTION (7).
That whenever conditions inside or under occupied business buildings provide extensive harborage for rats (in the opinion of the Health Officer) said Health Officer is empowered, after due notification in accordance with Section (3), to close such business buildings until such time as the conditions are abated by ratproofing and harborage removal, including, if necessary, the installation of suitable concrete floors in basements or replacement of wooden first or ground floors with concrete or other major repairs necessary to facilitate rat eradication.

SECTION (8).
That whenever conditions inside or under unoccupied business buildings provide extensive harborage for rats (in the opinion of the Health Officer)said Health Officer is empowered to require compliance with the provisions of Section (3) above, and, in the event that said conditions are not corrected in a period of sixty (60) days, or within the time to which a written extension may have been granted by the Health Officer, the Health Officer is empowered to institute condemnation and destruction proceedings.

SECTION (9).
That it shall be unlawful under the provisions of this ordinance for the occupant, owner, contractor, public utility company, plumber, or any other person to remove and fail to restore in like condition the ratproofing from any business building for any purpose. Further, it shall be unlawful for any person or agent to make any new openings that are not closed or sealed against the entrance of rats.

SECTION (10).
It shall be unlawful for any person, firm or corporation hereafter to construct, repair, or remodel any building, dwelling, stable, or market, or other structure whatsoever, unless such construction, repair, remodeling, or installation shall render the building or other structure ratproof in accordance with the regulations prescribed herein and hereunder. The provisions of this Section apply only to such construction, repairs, remodeling, or installation as affect the ratproof condition of any building or other structure.

SECTION (11).
It shall be unlawful for any person, firm, or corporation hereafter to occupy any new or existing business buildings wherein foodstuffs are to be stored, kept, handled, sold, held, or offered for sale without complying with Section (10) of this ordinance; and unless the provisions of this Section are complied with no city license or permit to conduct or carry on such business as defined above will be issued.

SECTION (12).
That all food and feed within the City of _____ for feeding chickens, cows, pigs, horses, and other animals shall be stored in rat-free and ratproof containers, compartments, or rooms unless stored in a ratproof building.

SECTION (13).
That within the corporate limits of the City of _____ all garbage or refuse consisting of waste animal or vegetable matter upon which rats may feed, and all small dead animals, shall be placed and stored until collected in covered metal containers of a type prescribed by the Health Officer. It is further declared unlawful for any person, firm or corporation to dump or place on any premises, land, or waterway, any dead animals, or any waste vegetable or animal matter of any kind.

SECTION (14).
That it shall be unlawful for any person to place, leave, dump, or permit to accumulate any garbage, rubbish, or trash in any building or on any premises, improved or vacant, or on any open lot or alley in the City of _____ so that same shall or may afford food or harborage for rats.

SECTION (15).

That it shall be unlawful for any person to permit to accumulate on any premises, improved or vacant, or on any open lot or alley in the City of _____ any lumber, boxes, barrels, bottles, cans, containers, or similar materials that may be permitted to remain thereon unless same shall be placed on open racks that are elevated not less than eighteen (18) inches above the ground, and evenly piled or stacked.

SECTION (16).

PENALTY: Any person, firm or corporation who shall violate any provision or provisions of this ordinance shall be deemed guilty of a misdemeanor and upon conviction shall be punished by a fine of not more than _____ dollars (_____) or imprisonment of not more than _____ days, (_____), or both. Each day's violation shall constitute a separate offense.

SECTION (17).

REPEAL CLAUSE: All ordinances or parts of ordinances in conflict herewith are hereby repealed to the extent of such conflict only.

SECTION (18).

SAVINGS CLAUSE: If any section, subsection, sentence, clause, or phrase of ordinance is for any reason held to be unconstitutional, void, or invalid, the validity of the remaining portions of this ordinance shall not be affected thereby.

SECTION (19).

This ordinance shall take affect immediately upon its passage, the matter being one of urgency and necessity and the public welfare requiring it.

Since the above ordinance does not take into consideration the special control measures required at ports, the following provisions should be added to ordinance when adopted in port cities:

1. Any vessels docking or landing at any port shall while laying at a dock or landing, be fended off at least four (4) feet at all times while at such docks or landings, and shall have placed on every line of any description leading from such vessel to the dock or shore, whether directly or indirectly, a rat shield or guard so constructed and attached that it will effectively prevent rats from passing along such line either from the vessel to the shore or vice versa.
2. No gang planks, ladders, skids or other devices or structures whereby rats and rodents may find egress from the vessel to such dock or landing, shall be allowed to extend from any vessel to such dock or landing except at times when such gang planks, etc., are actually in use; the latter shall be removed when not actually in use, and in all instances shall be removed at night, unless vessel is actually in process of discharging or loading cargo or passengers during the night hours.
3. All docks and wharves shall be equipped with fender logs, not less than thirty-six (36) inches in diameter at the smallest part, or other approved means of maintaining a clear distance of at least thirty-six (36) inches between the side of any vessel and the wharf.
4. Each spar and each chain, rope or line of any kind extending from any vessel, steamboat or other water craft to the dock or wharf, shall be equipped with and have properly and securely attached to it a rat shield or guard of such design and in such manner as is approved by the Health Officer.

If the municipality adopting the above ordinance felt the need to include detailed specification for ratproof construction and maintenance of building, it would be necessary to have specifications pertaining to (1) Material and methods of construction, (2) Footings and foundation walls, (3) Loading platforms, (4) Underground tunnels and multiple basements, (5) Foundation vents, (6) Residence building foundation vents, (7) Sidewalk vents, (8) Outside basement steps, (9) Coal chutes, (10) Ratproofing under buildings erected on piers, (11) Elevator shafts, (12) Floor drain plates, (13) Pipe chases, (14) Meter boxes, (15) Joints between side walls and foundation walls, (16) Exterior doors - business and residential, (17) Basement and first story windows - business and residential, (18) Second story and higher windows, (19) Exhaust fan openings, (20) Outside fire escapes, (21) Mail slots, (22) Junctions of roof and side walls, (23) Parapet walls, (24) Skylights, (25) Chimneys, (26) Water and sewer vent stacks, (27) Pent houses, (28) Spaces between attic floors and roofs, (29) Partition walls, (30) Opening for service pipes and utility lines, (31) Utility truckways, (32) Cellular pillars and columns, (33) Insulated boxed and structural beams, (34) Ventilation

systems, (35) Refrigerators, (36) Shelves, fixtures, counters and display fixtures, (37) Stable and food bins, (38) Open curbs and farmers' markets, (39) Wharves.

Chapter IX

Quality of Drinking Water

Water is the most universally used single necessity of life. It can be and has been one of the commonest and most treacherous vehicles for transmitting disease. A safe water supply is a most basic and elementary concern of the sanitarian. The logic of attaining a safe water supply can be sound only in the knowledge of water microbiology. The skill of the sanitarian in water safety, therefore, depends on his knowledge of this subject. He need not be a bacteriologist, but the fundamentals of water microbiology are his instruments of understanding the reasons why he performs his duties in protecting water supplies and how these duties are best carried out. He must know why he should routinely collect samples from public water supplies and ship them to the laboratory, why odors may appear in water supplies, the dynamics of the self-purification process, the rationale of coagulation, filtration and chlorination, the relation of the seasons and weather to water microbiology and the interpretation of bacteriological analysis. Without such knowledge his inspectional and survey duties relating to water safety become empty mechanical operations which are unreliable and non-adaptable to changing circumstances and give a sense of false security in the face of hazard; and his value as a consultant in the estimation of the community becomes negligible.

The microscopic organisms in water comprise bacteria, diatoms, green algae, blue-green algae, fungi, protozoa, rotifers, crustaceans, numerous small worms, insect larvae, and other organisms of minute size. Most of the bacteriological examination of water is done by means of liquid and solid culture media. The microscope is used to determine whether or not the cultures are composed of gram-negative bacilli. Other important uses of the microscope in the examination of water is to determine the presence or absence of microorganisms which produce objectionable tastes and odors, to determine the status of contamination and pollution, to aid in identifying the water.

The process of natural purification of water can be understood only by knowing the food habits of the living reagents found in polluted water, as was pointed out so well by Whipple:

Bacteria - Attack dissolved and suspended organic and mineral substances and convert them by aerobic or anaerobic digestion into end products of simpler chemical structure.

Algae - Use up carbon dioxide and produce oxygen, utilize simpler inorganic food substances resulting from bacterial activity and also certain nitrogenous organic substances.

Protozoa - Live on organic matter. Many species prey upon bacteria. Chlorophyll-bearing protozoa act similarly to algae.

Rotifera and Crustacea - Consume algae and prey on protozoa. Saprophytic organisms feed on decaying materials.

Large Aquatic Plants - Act similarly to algae; rooted forms utilize food substances contained in bottom deposits.

Large Aquatic Animals - "Work over" mud deposits. Insect larvae utilize food substances contained in the water and the sediments. Fish live on plankton and insect larvae.

The sanitary quality of water cannot be definitely shown from a microscopic examination. The microscopic examination of water is of value in supplementing the chemical and bacterial analysis. It may explain the cause of odors and tastes in water. It may explain certain chemical determinations such as albuminoid ammonia, dissolved oxygen, etc. It may indicate sewage contamination. It may suggest the state of self-purification of polluted and contaminated water. It may identify the source of the water. A final judgment of potability should never be based upon the bacteriological examination alone but should be combined with a sanitary survey and other laboratory tests.

Surface waters are usually rich in microscopic life, while ground waters are comparatively free. However, as soon as ground waters stand in piped or are exposed to light, microscopic organisms may develop.

There are various ways of classifying the bacteria found in water. Whatever method is used, one finds the categories to be overlapping. This is so because it is difficult to separate natural water, soil, and sewage from intermingling. There are many types of bacterial genera found in surface water. The most common genera are: Micrococcus, Serratia, Chromobacter, Achromobacter, Flavobacterium, Alcaligenes, Pseudomonas, Proteus, Bacillus, Aerobacter, Lactobacillus,

Clostridium, Actinomyces, Vibrio; also various yeasts and molds.

Topley and Wilson divide the bacteria found in water into three groups:

1. Natural Water Bacteria

In this group are included those organisms that are commonly found in waters free of gross contamination or pollution. They may be subdivided as follows:

Bacilli

a. Fluorescent - those which produce a fluorescent pigment on culture media.

b. Chromogenic - those which produce red, orange, yellow, or violet pigment on culture media.

c. Non-chromogenic - those which produce no pigment on culture media.

Cocci

a. Chromogenic - these generally produce a yellow pigment on culture media.

b. Non-chromogenic - these produce no pigment on culture media.

Sarcina - these are a group that are distinguished by their peculiar arrangement in bundle formation.

2. Soil Bacteria

These organisms, though not normal inhabitants of water, are frequently washed into it during heavy rains. Most of them are aerobic spore-bearing bacilli, such as Bacillus subtilis, Bacillus vulgatus. Others, such as Aerobacter aerogenes and Aerobacter cloacae, which appear to live most frequently on grain and plants, and which may conveniently be treated as soil organisms, are aerobic non-sporing bacilli.

3. Sewage Bacteria

Many of the organisms of this group are normal inhabitants of the intestines of man and animals. Others live chiefly on decomposing organic matter of either animal or vegetable origin. Occasionally pathogenic organisms are included.

Intestinal Bacteria - Escherichia coli is truly of intestinal origin. Escherichia freundi is closely related to Escherichia coli but is less frequently of intestinal origin; the same is true for the Aerobactor group of microorganisms. There is a group of streptococci, named Enterococci, which is common in the intestinal tract, such as Streptococcus fecalis. The anaerobe, Clostridium perfringens, is found commonly in the intestinal tract and in the soil. The most important pathogenic bacteria which may be found in the intestinal tract are of the Salmonella group, the Shigella group and Vibrio cholerae.

Sewage Bacteria - These are composed mostly of bacteria from the soil and the intestinal tract. Besides those mentioned as intestinal bacteria, the common sewage bacteria are: The Proteus group, such as, Proteus vulgaris, many species of the genus Clostridium, Bacillus vulgatus, species of the genera Pseudomonas, Cytophaga, Thiobacillus; the orders Actinomycetales, Chlamydobacteriales and Thiobacteriales; also yeasts and molds.

Plants and Animals in Water as related to Tastes, Odors, and Toxins: Because tastes and odors of water are important in its usability and because various plant and animal organisms are important factors in producing such tastes and odors, the following classification is presented:

1. Rooted Aquatic Vegetation - such as cattails, lillies, eel-grass or seaweed. These are usually beneficial to water supplies except when present in abnormal quantities because they liberate oxygen into the water.

2. Bacteria

a. Iron Bacteria belonging to orders chlamydobacteriales and Pseudomonadales*: Three types are important, namely, Crenothrix, Leptothrix (Fig. 1), and Gallionella. These can live without oxygen if considerable carbon-dioxide and iron be present. Therefore, they thrive on ground water. They

* The most familiar problems associated with water producing wells are those of plugging due to the build-up of carbonates and oxides from the water or from the action of water on deposits or the metals of the installation. In some cases clay and silt can be partially responsible for reduced water output.

Much less familiar, but often of equal or greater importance, are difficulties of corrosion and of screen and strata plugging due to bacterial activity. Many species cause plugging with their by-products or their bodies. One large group that can cause severe difficulties is iron bacteria called Gallionella ferruginea. Reduced water output can be caused by precipitated iron and masses of cells and slime formed by these species. They can remove large quantities of iron from the water by oxidizing soluble ferrous iron to ferric iron which then flocculates as the insoluble ferric hydroxide. The end result is that plugging as well as corrosion can occur. The proliferation of Gallionella throughout the water can also affect its color and odor. Hydroxyacetic acid has been found to be effective in removing and killing these iron bacteria. A concentration of 5% of this acid based on the static volume in the well is generally employed, although higher concentration may be necessary in severe cases of iron problems. It can be used alone or mixed with other acids such as hydrochloric or sulfamic. It is non-fuming and its corrosive properties are sufficiently low to obviate the use of special inhibitors.

assimilate iron as food. Their growth may produce objectionable odors and partial clogging of mains.

b. Sulphur Bacteria belonging to order Thiobacteriales: Only one, namely Beggiatoa (Fig. 1) is important in water. It grows in presence of hydrogen sulphide and can assimilate sulphur. It may be present in ground water containing hydrogen sulphide.

Fig. 1 Schizomycetes (Higher Bacteria)

c. Sewage fungi is a misnomer given to a group of bacteria not ordinarily found in water, but when present indicate recent heavy sewage pollutions of streams. Among these are some Actinomyces which produce offensive odor and taste in water.

3. Fungi are not normally found in water except when subject to serious pollution and contamination by sewage or other organic wastes. The grayish white deposit on the beds of heavily polluted streams is due to these organisms.

4. Algae

a. Blue Green Algae or Water Bloom (Cyanophyceae or Myxophyceae (Fig. 2) are troublesome only in hot weather. Some blue algae have been found to produce toxic substances in water.

Anabaena - is very common; gives a moldy, grassy odor in water; large numbers give a "pig pen" odor to water.

Oscillatoria - is very common, but does not ordinarily produce odors in water.

Aphanizomenon - has a grassy, or nasturtium, or "pig pen" odor.

Coelosphaerium - has sweet, grassy odor.

Clathrocystis - has sweet, grassy odor.

Cylindrospermum - has grassy odor.

Rivularia - has grassy and moldy odor.

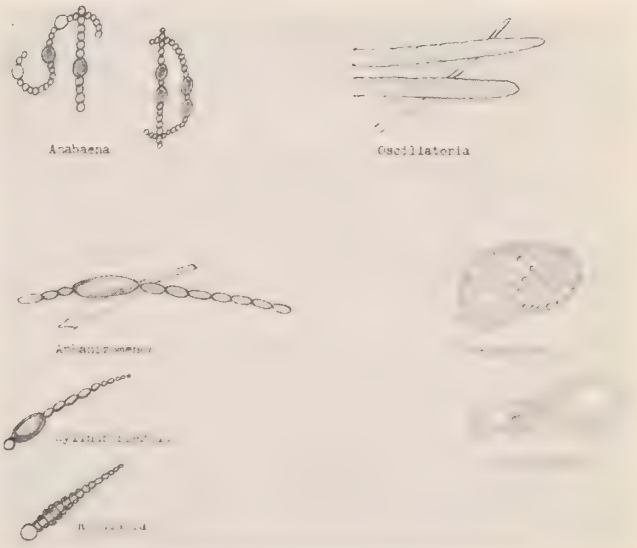


Fig. 2 Cyanophyceae or Myxophyceae or Blue-green Algae

b. Green Algae (Chlorophyceae Fig. 3). These are most common in summer.

Hydrodictyon - forms nets, therefore called "water net" and produces an offensive odor.

Volvox - grows in clusters; gives fishy odor to water.

Eudorina - grows in smaller clusters than Volvox, has a faintly fishy odor.

Pandorina - grows in smaller clusters than Eudorina; gives faintly fishy odor and taste to water and is very resistant to copper sulphate.

Spirogyra - grows in thread-like clusters; is common but does not produce objectionable odor.

Conferva - thread-like alga, does not cause objectionable odor.

Dictyosphaerium - has grassy, nasturtium or fishy odor.

c. Diatoms - cause brownish film on stones; most prevalent in spring and early winter; thrive in winter under ice; produce objectionable tastes and odors in winter months. The following diatoms are common:

Asterionella - gives aromatic geranium odor in lower concentrations and fishy odor in higher concentrations.

Tabellaria - has a slightly fishy odor in high concentrations.

Synedra - produces an objectionable earthy odor in large concentrations.

Cyclotella - has a faintly aromatic odor.

Meridion - has a faintly aromatic odor.

Diatoma - has a faintly aromatic odor.

Animals.

1. Protozoa (Fig. 4)

Dinobyron - gives fishy odor and taste to water.

Euglena - collects on surface of stagnant water producing a reddish or greenish scum. Imparts a fishy odor to water.

Uroglenopsis - imparts an oily and fishy taste and odor to water.

Synura - one of the most troublesome of micro-organisms in water. It imparts a very objectionable cucumber or fishy taste and odor to water.

Mallomonas - has an aromatic geranium odor but fishy in large concentrations.

Cryptomonas - has a candied violet odor

Peridinium - has a clam-shell odor.

Ceratium - has a vile fishy stench.

Glenodinium - has a fishy odor.

2. Rotifera. These microscopic animals produce no odor nor taste in water.

3. Crustacea: (Fig. 5) These are of no importance to water supplies except that they may clog filters. However, their appearance in the distribution system usually indicates a defective filter bed.

4. Adult Aquatic Insects: These are ordinarily of no significance but they have been known to develop to such an extent in open water reservoirs or open stand pipes containing well water as to produce objectionable tastes in water. These are not destroyed by copper sulphate or chlorine.

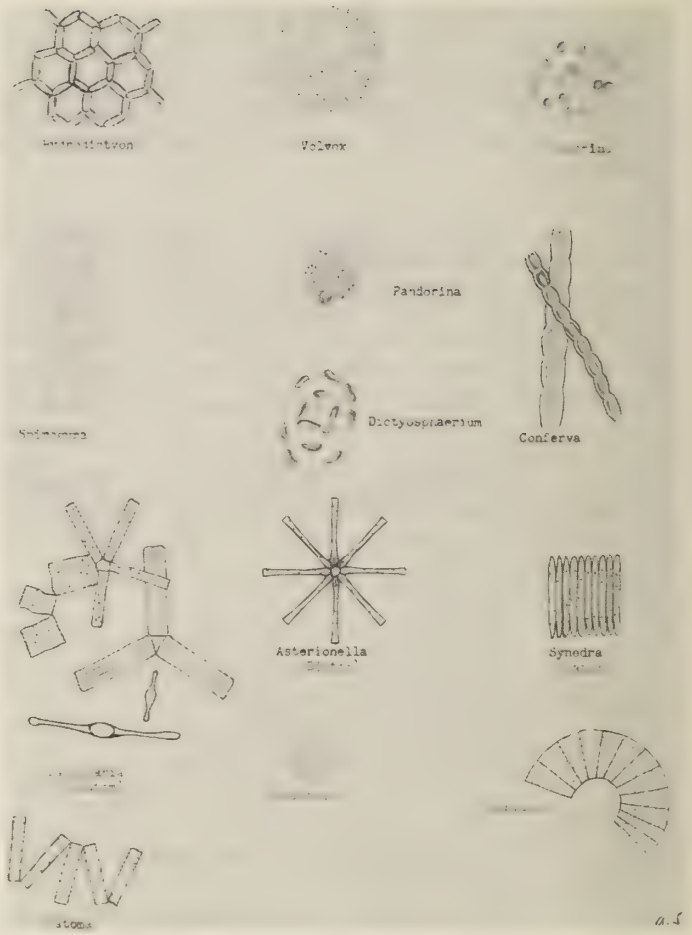


Fig. 3 Chlorophyceae or Green Algae

5. Worms are of no significance in water supplies. They are found at the bottom of reservoirs and are useful in digesting organic material.

The possibility that certain tastes and odors in water have, in the past, been attributed mistakenly to algae has recently* been brought to light. It was demonstrated that actinomycetes of genus Streptomyces, isolated from the bottom mud of reservoirs, were responsible for offensive taste and odor of water rather than the algae present. The concentration of Streptomyces was shown to be in direct proportion to certain type of organic matter. In reservoirs with considerable areas of shallow water supporting rich growths of cattails, sawgrass, eelgrass, bulrushed, water lilies, button willow, and

Fig. 4 Protozoa

*Actinomycetes and Common Tastes and Odors, Silvey J. K. G., Russell J. C., Redden D. R., McCormick W. C., Jour. Am. Water Works Assn., Vol. 42, No. 11, p. 1018, Nov. 1950.

black willow, one may find luxuriant growths of actinomycetes during warm season. The minimum temperature at which the spores will germinate and produce is 15°C., and as the temperature increases so do the growth activities. Where there is a dearth of the above mentioned vegetation, the higher the concentration of planktons and algae the greater is the growth of Streptomyces. The greater the alkalinity the more prolific is the growth of actinomycetes. In a like manner, mineral content supports the growth of these organisms. The odors and tastes produced by Streptomycetes may be attributed to simple and complex amines, saturated fatty acids, and unsaturated aromatic compounds which are by-products of the metabolism of these organisms. The concentration necessary to produce noticable taste and odor (manurial-like) is approximately 0.2 p.p.m.

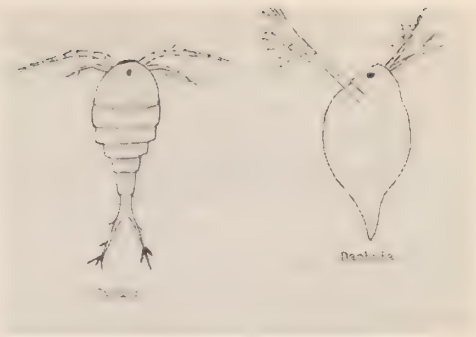


Fig. 5 Crustacea

It has been definitely established* that blue algae, floating on pond or lake waters and blown to the shores to form thick mats, may produce highly toxic substances in the water which, when drunk by animals, can cause death within 3 to 24 hours. These toxins have also been produced by laboratory cultures and have been found to be fatally toxic to animals.

The poison has not been defined and is probably a mixture of several. It exists outside the cells in the water around the algae, penetrates animal membranes by dialysis, is non-volatile and practically heat stable in dry and in liquid form. It is soluble in water, alcohol, and acetone; not soluble in chloroform; and specific tests for cyanide, strychnine alkaloid and other poisons have all been negative.

There seems no doubt that the poison is toxic to all warm blooded animals and therefore, also to man. Gastroenteric outbreaks, water-borne on the basis of epidemiological evidence, have occurred in cities of which the water supplies in all instances met with the approved bacterial standard, and extensive algae blooms usually preceded or occurred concurrently with the reported gastroenteric outbreaks.

Food, as well as water, may affect man's health in connection with this phenomenon. Algae poisoning may be involved in producing the syndrome known as Haff's disease in Europe (East Prussia, Sweden) which is associated with the consumption of fish or fish livers, although they be thoroughly cooked. It seems thereby possible that the toxic agent in the water was concentrated in the flesh or liver of the fish.

The toxic agent is not removed by a laboratory equivalent of a water purification process of coagulation, filtration, and chlorination. Even massive treatment with activated carbon will not entirely remove the toxin.

It should be noted that "duck sickness" (in late 1932, 150,000 dead ducks were found near the north end of Great Salt Lake) has so far been shown to be caused by Clostridium botulinum type C and not by blue green algae poisoning, but recently a minor outbreak could be traced to this cause.

Factors Determining the Kinds and Numbers of Bacteria in Water

Types of Water

Waters may be divided, according to their source, into (1) surface and (2) ground waters. The former comprise all those that are found on or near the surface of the earth, and that have not been filtered through any considerable thickness of soil; the latter comprise those which, in order to reach the underground stratum that they occupy, have percolated from several feet to several hundred feet through porous layers of soil. Since surface waters are frequently exposed to contamination from dust, soil, sewage, factory wastes, and other decomposing organic matter,

*Toxic Plankton, Theodore A. Olsen, 1951 Inservice Training Course in Water Works Problems, University of Minnesota, School of Public Health.

they may contain large numbers of bacteria, many of which are of intestinal origin. Ground waters, on the other hand, are generally pure, having had most of their surface contaminants filtered off on their downward passage through the soil; and though it be not unusual to find bacteria in larger numbers than one would expect, these are generally of a harmless type.

Surface Waters

a. Rain. In falling to the earth, the raindrops come into contact with particles of suspended dust, and carry these down with them. The more dust there is in the atmosphere the greater is the bacterial count. Therefore the greatest number of organisms found in rain water is in the warm dusty months.

b. Snow. This tends to be less pure than rain, probably because the snow flakes have a greater surface on which to collect suspended particles in the atmosphere; and also because its low temperature conduces to the survival of bacteria. In snow situated on the tops of high mountains where Pasteur found the air to be practically sterile, there are hardly any organisms.

c. Hail. Curiously enough, hail contains more bacteria than either rain or snow. During the formation of hail, it seems probable that rapidly ascending currents of air carry the raindrops up into a region of atmosphere where they are solidified; falling down they are melted, and again swept up and frozen. After they have been frozen and thawed a number of times, the hailstones are thrown out on the periphery of the storm center and finally come to earth. It is suggested that the air currents carry up to the cloud regions quantities of dust which are thus incorporated into the hail. It is difficult to explain otherwise the presence in it of vegetable cells and of fluorescent and soil bacteria.

d. Ice. The number of organisms in ice depends on the nature of the water from which the ice is formed. With the exception of the ice of glaciers, it is generally impure. Its low temperature is favorable to the survival of most bacteria, hence the self-purification that occurs in waters on storage occurs hardly at all, or very slowly, in ice.

e. Upland Surface Waters. If derived from open wasteland that is protected from human and animal excretion, these waters are relatively pure. Most of the organisms they contain belong to the soil group of bacteria.

f. Rivers. In most countries, rivers are heavily contaminated and contain not only natural and soil bacteria but large numbers of organisms derived from sewage.

g. Lake Waters. Owing to the natural storage of water in lakes, there is a continuous process of self-purification occurring; hence lake water usually is purer than streams that feed it. Water taken from the middle of a lake contains fewer organisms than that taken near the shore.

h. Sea Water. The number of bacteria in sea water is generally less than in fresh. In deep sea the bacteria seem to be distributed evenly, there being almost as many near the bottom as on the surface. The ooze on the bed of the ocean is very rich in bacteria.

Ground Waters

Some of the purest waters that we know come from deep wells and springs. The purity of springs depends mainly on their source and surroundings. In waters which have percolated through thick strata, the flora differs from that in surface waters; usually the chromogenic type of bacteria are found in this case.

Shallow wells, if protected from contamination in the immediate vicinity by concrete sides to a depth of at least ten feet, and if provided with sanitary pump system, may contain relatively few bacteria. This may not always be true, since the water at the shallow level may be grossly contaminated due to the character of the soil porosity and formations of the earth strata. It can be generally expected that open wells or ill outfitted wells are heavily contaminated from dust and surface washings.

It can generally be said that the further water percolates through the ground the purer it will be if no other factors tend to vitiate the filteration effect on the water, such as deep crevices in the earth, extensive layers of gravel unmixed with sand, and unexpected peculiarities in the earth's strata. The types of earth which give the best water supplies are those whose particles are not so fine or cemented together as to prevent ample water to percolate through it, and those whose particles are not so large as to allow too rapid percolation and therefore too little effective filtration.

The following table may be helpful:

Table 1

	Minimum Filtration but Ample Water Supply	Adequate Filtration but Diminished Water Supply	Adequate Filtration and Adequate Water Supply
Lime Stone)	(xxxx		(xxxx
Sand Stone)	(When creviced		(When not creviced
Fine Sand		xxxx	xx
Clay		xx	
Sandy Loam*			xxxx
Coarse Sand	x		xx
Gravel	xxxx		

Each x emphasizes the affirmative

Nutrition

The amount of available food supply is probably the most important factor of all in determining the number of bacteria in a given water. When organic matter is plentiful, organisms abound; when it is scarce, they are few, and tend to die out.

Temperature

The effect of temperature varies with amount of organic matter present. A rise of temperature in a water containing ample food supply for the bacteria causes them to multiply rapidly; but when the organic matter is small in quantity, a rise in temperature has the reverse effect; this is probably due to early exhaustion of the food supply, and the consequent diminution in the rate of multiplication of the bacteria.

A low temperature, independent of the amount of organic matter present, favors the survival though not the multiplication of bacteria. Houston (1913) added typhoid bacilli to raw Thames water and maintained the samples at temperatures varying from $0^{\circ}C.$ to $37^{\circ}C.$ The initial number of organisms was 103,328 per c.c. of water. The following table illustrates the results:

Table 2

	No. of Bacilli per c.c. Surviving after Weeks								
Degrees	1	2	3	4	5	6	7	8	9 weeks
$0^{\circ}C.$	47,766	980	65	34	3	3	2	1	0.0
$5^{\circ}C.$	14,894	26	6	3	0.3	0.1	0.0	-	-
$10^{\circ}C.$	69	14	3	0.3	0.0	-	-	-	-
$18^{\circ}C.$	39	3	0.4	0.0	-	-	-	-	-
$27^{\circ}C.$	19	0.1	0.0	-	-	-	-	-	-
$37^{\circ}C.$	5	0.0	-	-	-	-	-	-	-

(From "Principles of Bacteriology and Immunology" by Topley and Wilson)

Light

It has been asserted that the ultra-violet rays of the sun play an effective part in destroying micro-organisms in water. Procaccini (1893) placed drain water from which the coarser particles had been removed, in glass cylinders 50 cms. deep and exposed them for 6 hours to the Italian sun in June. A control cylinder was protected from the light. The results obtained were as follows:

*Loam is a friable mixture of clay, sand, and organic matter.

Table 3

	Insolated cylinder Bact. per c.c.	Darkened cylinder Bact. per c.c.
Before exposure		
Surface	4,900	4,900
Middle	4,510	4,510
Bottom	6,781	6,781
After exposure		
Surface	0	7,261
Middle	2	9,051
Bottom	8	12,591

(From "Principles of Bacteriology and Immunology" by Topley and Wilson)

It would appear that under laboratory conditions the actinic rays of the sun may exert a bactericidal effect. In nature, however, the conditions are altered. One of the main factors hindering the rays is the opacity of the water which prevents their penetration for more than a short distance. Even in clear water, it is doubtful if the rays be active for more than a distance of 5 feet from the surface. Another factor is the movement of the water which may prevent any single organism from being subjected to the rays for a sufficient time to kill it. Ultraviolet rays generated from a mercury vapour lamp have been used in the artificial purification of water. This bactericidal method requires that the water be exposed in shallow layers.

Acidity

Many natural waters have an acid reaction. Though it be difficult to estimate the effect of acidity on the destruction of bacteria and on the inhibition of their growth, there is little doubt that it does play a considerable part in purifying some waters. It appears that the disinfectant action of mineral acids is proportional to the amount of free hydrogen (ionic hydrogen) per unit volume. The organic acids are only slightly ionized so that their H-ion concentration is relatively low. As, however, they have a marked germicidal effect, it must be concluded that this is a property of the whole molecule, or possibly to some extent of the anion (negatively charged ion). The hydrogen ion is positively charged.

Salinity

The effect of salt solutions on growth of bacteria depends upon the concentrations of the solutions, the types of salts, and the combination of salts. Such salts as $CaCl_2$, $MgCl_2$, NH_4Cl, NaCl, and KCl stimulate Escherichia coli in very low concentrations and inhibit growth in higher concentrations. NaCl in .85% solution causes rapid disintegration of the meningococcus, but when a calcium salt is added to the solution the disintegration will not occur. It is probably this factor of quantity and kinds of salts in solution that accounts for the difference both in the number and types of bacteria found in sea water.

Dissolved Oxygen

Salmonella typhi and Escherichia coli remain viable in sterile water containing dissolved oxygen much longer than in water kept under anaerobic conditions. Salmonella typhi, in an experiment, survived in filtered tap water exposed to the air at room temperature for nearly two months, but died in 4 days in an atmosphere of hydrogen. This suggests why this organism dies more rapidly in polluted than in pure water, and is one of the reasons it survives for a shorter time in summer than in winter. The importance of free oxygen in favoring growth and survival of aerobic and facultative anaerobic organisms has already been explained elsewhere.

Protozoal Content

A number of studies have indicated that the presence of large numbers of protozoa of the flagellate and infusoria types will cause a destruction of the bacterial life of the water.

Rainfall

The effect of rainfall on the bacterial content of a water is complicated. Rain, falling after a drought, washes large numbers of soil organisms into the water, and hence increases the number of bacteria. If the rain continue for some days, relatively few organisms may be carried in during the later period of rainfall, so that the stream is diluted with water purer than its own. Its bacterial content therefore drops. A relatively pure stream may be contaminated by rain; an impure stream may be benefited by dilution. As a rule, rivers and upland surface waters contain their greatest numbers of bacteria after heavy rainfall.

Season

The monthly variation in the bacterial content of waters depends chiefly on the temperature and rainfall. The highest counts in the Thames River are found in the winter months when the temperature is low and the rainfall greatest. In the summer many sources of pollution and contamination may dry up and much of the water in the rivers may be filtered water, derived from underground sources of supply, hence the bacterial content may be low. In countries in which the water supply is augmented by melting snows, the bacterial content rises considerably in spring time.

Storage

The simple storage of water in a reservoir suffices to decrease its bacterial content enormously. Storage acts in 3 ways:

1) Sedimentation: The organisms adhering to particles of suspended matter and those in clumps sink to the bottom leaving the supernatant water purer.

2) Equalization: This factor comes into play only when several waters of different qualities are collected into one reservoir. It ensures a thorough mixing of the different waters, and prevents the excess distribution of a bad supply on any one day. Even in a river, water may not be homogeneous; samples taken from one side may be different in their bacterial content from those taken near the other side. In a reservoir, natural or artificial, homogeneity is attained.

3) Devitalization: The organisms die in large numbers, probably from lack of food supply, and ingestion by protozoa. It is probably owing to storage that lake waters are so much purer than the streams that feed them. Some rivers with a very low gradient may offer conditions suitable for sedimentation.

Filtration

Natural filtration occurs on a large scale resulting in the accumulation of the underground deposites of water that are tapped by deep wells and springs. Its efficacy in the removal of bacteria depends on the nature of the soil and the depth of the strata penetrated. In loose, porous, soils a greater depth must be traversed to ensure the same degree of purification that is attained by filtration through a more compact soil. Evidence suggests that, in a soil of moderate density, the greater part of the bacteria are removed in the first 10 or 15 feet. This is the reason why deep well water is so pure. Artifically, sand filtration is used to remove bacteria from water in order to render it potable.

Bacteriophage

A bacteriophage is an ultra-microscopic living agent which attacks specific organisms and causes their destruction. It is known that certain types of microbes are unable to survive long in certain waters. Examples: The cholera vibrio is unable to survive long in the waters of the Ganges River, the typhoid bacilli are unable to survive long in the Rhone River, the Shiga dysentery bacilli are unable to survive long in sea water at Harve. It is believed that these and other similar specified inhibitory actions of waters may be due to the action of bacteriophage. There appears to be a close similarity between filterable viruses and bacteriophages. Bacteriophages are pathogenic to particular types of bacteria; they are parasites of bacteria.

Self-Purification of Rivers

From what has already been said, it is clear that the number of bacteria in a particular sample of water is determined by several factors, the precise effect of which it is difficult to assess. It is also clear that such factors as absence of organic matter, the presence of numerous protozoa, a high acidity, the opportunity for sedimentation, high degree of dilution, high degree of oxidation and reduction, and a large amount of sunlight are able to bring about a considerable reduction in the bacterial flora. It is not surprising, therefore, that rivers that have been heavily contaminated by sewage may regain their natural purity after flowing for some distance. Jordon's (1900)

observations on the Illinois River are of interest. The portion of the river that he examined was between Morris and Ottawa. Nine miles above Morris two tributaries unite, the relatively pure Kankaker, and the Desplaines laden with Chicago sewage. During its flow of 24 miles from Morris to Ottawa the river improved in purity in spite of the absence of dilution with fresh water. The observations were made in October and November when there was neither much sun nor rain.

Table 4

Station and Location	Distance from Morris	No. Colonies per c. c.			No. of Hourly Analyses
		Rt. Bank	Middle	Lf. Bank	
Upper Station, Morris	————————	261,000	204,000	29,000	3
Middle Station, Seneca	12 miles (24 Hours)	100,000	49,000	35,000	2
Lower Station, Ottawa	24 miles (48 Hours	11,500	10,700	13,500	2

(From "Principles of Bacteriology and Immunology" by Topley and Wilson)

The extraordinary degree of purification that occurred was accounted for partly by the slow movement of the river which permitted sedimentation to occur, and partly by the absence of sufficient food-supply to support the large number of contaminating organisms.

The self-purification of streams heavily contaminated by sewage sets into motion a series of physical, chemical, and biological reactions that are more or less interdependent. The activity set up may be divided into 4 zones:

1. Zone of Degradation

The stretch of stream confined to just below the outfall of sewage.

a) The water is turbid and of gray color.

b) There is a decreased penetration of sunlight into the water and a decrease in green plant life such as algae.

c) The bacterial activity is increased, producing a decomposition of organic material. Fish may still be present, feeding on the fresh organic matter. But the increased number of micro-organisms causes the free oxygen to be used up quicker than reaeration can supply it. Reduction of oxygen is about 40%. This may cause the death of fish and higher forms of organic life that require a certain adequate amount of dissolved oxygen in the water for maintaining life. Five parts per million (5 p. p. m.) of dissolved oxygen is usually considered as a minimum for maintenance of normal aquatic life.

d) Suspended matter begins to settle to the floor of the stream, producing a sludge in which red worms, fungi, bacteria and protozoa live. A typical bottom worm is Limnodrilus* and Tubifex.

II Zone of Active Decomposition

A longer stretch of stream below zone of degradation.

a) There is heavy pollution and contamination, grayish color, offensive odor and gas bubbles, and a sticky black sludge on the floor of the stream. No fish life is present.

b) Further decomposition of organic matter occurs by reducing and splitting processes which produce soluble and gaseous compounds. The end products become very much simplified.

c) If free or dissolved oxygen be plentiful no nuisance is created. If free oxygen be low, aerobic bacteria are replaced by anaerobic bacteria, and the latter extract their oxygen from such minerals as nitrates, nitrites, and sulphates, and finally from the organic material itself. The increased growth of anaerobic organisms results in septic conditions which cause extreme offensiveness. The gases given off are hydrogen, nitrogen, methane, hydrogen sulfide and other odorous gases. Under these conditions the free oxygen may drop from 40% to 0 and further down the zone rise again to around 40% oxygen.

d) At the end of this zone, the reaeration may be great enough to allow sufficient free oxygen to become dissolved in the water for more highly organized life to become established. There is also a decrease in micro-organisms.

*Limnodrilus ingests subsurface mud and discharges fecal pellets daily equal to 45 times the length of the worm.

Table 5. Living Organisms in Water

Partial List of Microorganisms That are Troublesome in Water Supplies, Together with a Statement of the Amount of Chemical Required for their Extermination[a]

Organism	Odor	$CuSO_4$,[b] ppm	Cl_2,[c] ppm	Organism	Odor	$CuSO_4$,[b] ppm	Cl_2,[c] ppm
Diatoms:							
Asterionella[d]	AGF	0.12-0.20	0.5-1.0	Cyanophyceae (continued)			
Cyclotella[d,e]	fA	. . . . .	1.0	Cylindospermum	G	0.12	
Diatoma[e]	fA			Gloeocapsa (red)		0.24	
Fragalaria[e]		0.25		Microcystis		0.2	
Melosira [d,e,f,]		0.20-0.33		Oscillaria[e]		0.2-0.5	
Meridion	A			Rivularia	MG		
Navicula[e]		0.07		Schizomycetes:			
Nitzchia[f]		0.05		Beggiatoa[e]	vO,D	5	
Synedra[d,e]	EA	0.36-0.5	1.0	Cladothrix		0.2	
Stephanodiscus		0.33		Crenothrix[e]	vO,D[g]	0.33-0.5	0.5-1.0
Tabellaria	AGF	0.12-0.5	0.5-1	Leptothrix			
Chlorophyceae:				Sphaerptilus natans	vO,D	0.4	
Cladaphora		0.5		Spirophyllum			0.25
Closterium		0.17		Thiothrix[d,e]	vO,D		0.5-1
Coealstrum[e]		0.05-0.33	1.0	Fungi:			
Conferva[e]		0.25		Achyla			0.6
Desmidium		2.0		Leptomitus		0.4	
Dictyosphaerium	GNF		0.5-1	Saprolegnia		0.18	
Draparnaldia		0.33		Miscellaneous:			
Eudorina	fF	2-10		Chara[e]		0.1-0.5	
Entomorpha		0.5		Chironomus*			15-50
Gloeocystis	O	0.5		Naís			1.0
Hydrodictyon	vO	0.1		Nitella flexilis[h]		0.1-0.18	
Microspora		0.4		Patomogeton[e]		0.3-0.8	
Palmella		2.0		Protozoa:			
Pandorina	fF	2-10		Busaria	im,sm,F	0.33	0.3-1
Protococcus			1.0	Ceratium	VF	0.24-0.33	0.3-1
Raphidium		1.0		Chlamydomonas		0.36-1.0	
Scenedusmus		1.0		Cryptomonas	cv	0.5	
Spirogyra[e]		0.12	0.7-1.5	Dinobryon[d]	AVF	0.18	0.5
Staurastium	G	1.5		E.histolytica		25-100	0.5
Tetrastrum			1	Euglena		0.5	
Ulothrix		0.2		Glenodinium	F	0.5	
Volvox[d]	F	0.25	0.3-1	Mallomonas	AVF	0.5	
Zygnema		0.50		Peridinium	F'	0.5-2	
Cyanophyceae:				Synura[d]	CM'FB	0.12-0.25	0.3-1
Anabena[d]	MGV	0.12-0.48	0.5-1	Uroglena[d]	FO'C'	0.05-0.2	0.3-1
Aphanizomenon[d]	MGV	0.12-0.5	0.5-1	Rotifer, Stentor			0.24
Clathrocystis	SGV	0.12-0.25	0.5-1	Crustacea:			
Coleosphaerium[d]	SG	0.2-0.33	0.5-1	Cyclops[d,e,f,]			1-3
				Daphnia		2.0	1-3

A - aromatic. B = bitter. C = cucumber. c' = cod-liver oil. cv - candied violets. D = decayed. E - earthy. F = fishy. F' - fishy, like clamshells. G - grassy. im - Irish moss. M - moldy. M' - muskmelon. N - nasturtium. O = offensive. O' = oily. S - sweet. sm = salt marsh. V = vile. f - faint. v - very.

[a] From W. C. Purdy Methods for the Biological Examination of Water, Proc. 9th Ann.Water Works School, Univ. Kansas, 1931, and from other sources.

[b] Residual, in most cases.

[c] Applied.

[d] These organisms have been affected by chlorine, producing a characteristic odor. In many cases they have been controlled by doses of chlorine ranging from 0.3 to 3.0 ppm, depending largely on the amount of organisms present.

[e] These organisms have caused troubles other than odor.

[f] These may be controlled by excess lime, 5 ppm in the case of diatoms.

[g] Medicinal with chlorine.

[h] Objectionable.

* Bloodworm

III Zone of Recovery

The next stretch in the stream is where mineralization takes place and the former appearance and aquatic life is recovered.

a) The floor of the stream is covered with granular deposits rather than a sticky sludge.
b) No offensive odors of gas bubbles issue forth.
c) Free oxygen is increased to above 40%.
d) Nitrogen end-products are produced; nitrites become nitrates, sulphur becomes sulphates, carbon becomes carbonates.
e) Green algae appear in the water as sun rays penetrate deeper below the surface, and also large aquatic vegetation begins to grow.
f) Life such as crustacae, rotifers, insect larvae, and fish appears. Fungi diminish.

IV Zone of Cleaner Water

This is the next zone where the normal flora and fauna of the stream abound. Free oxygen approaches saturation. (The sanitarian should review the nitrogen-cycle in studying the above process of self-purification).

Public Health Service Drinking Waters Standards--1962

The recommendations of the U. S. Public Health Service Advisory Committee on Drinking water Standards were reached from an analysis of results of bacterial counts on water supplies over a long number of years. These standards may be interpreted as meaning that if a water supply complied with them, it would contain, on an average, less than 1 coliform bacillus per 100 ml. of water, and that over a long period of time the count would not vary above 10 coliform bacilli per 100 ml. of water. The following standards supersede those of 1946.

Definition of Terms

Adequate protection by natural means involves one or more of the following processes of nature that produces water consistently meeting the requirements of these Standards: dilution, storage, sedimentation, sunlight, aeration, and the associated physical and biological processes which tend to accomplish natural purification in surface waters, and, in the case of ground waters, the natural purification of waters by infiltration through soil and percolation through underlying material and storage below the ground water table.

Adequate protection by treatment means any one or any combination of the controlled processes of coagulation, sedimentation, absorption, filtration, disinfection, or other processes which produce a water consistently meeting the requirement of these Standards. This protection also includes processes which are appropriate to the source of supply; works which are of adequate capacity to meet maximum demands without creating health hazards, and which are located, designed, and constructed to eliminate or prevent pollution; and conscientious operation by well-trained and competent personnel whose qualifications are commensurate with the responsibilities of the position and acceptable to the Reporting Agency and the Certifying Authority.

Certifying Authority means the Surgeon General of the U.S. Public Health Service or his duly authorized representatives. Reference to the Certifying Authority is applicable only for those water supplies to be certified for use on carriers subject to the Public Health Service Regulations.

The coliform group includes all organisms considered in the coliform group as set forth in Standard Methods for the Examination of Water and Wastewater, current edition, prepared and published jointly by the American Public Health Association, American Water Works Association, and Water Pollution Control Federation.

Health hazards means any conditions, devices, or practices in the water supply system and its operation which create, or may create, a danger to the health and well-being of the water consumer. An example of a health hazard is a structural defect in the water supply system, whether of location, design, or construction, which may regularly or occasionally prevent satisfactory purification of the water supply or cause it to be polluted from extraneous sources.

Pollution, as used in these Standards, means the presence of any foreign substance (organic, inorganic, radiological, or biological) in water which tends to degrade its quality so as to constitute a hazard or impair the usefulness of the water.

Reporting Agencies means the respective official State health agencies or their designated representatives.

The standard sample for the bacteriological test shall consist of:

For the bacteriological fermentation tube test, five (5) standard portions of either:
a) ten milliliters (10 ml)
b) one hundred milliliters (100 ml)

For the membrane filter technique, not less than fifty milliliters (50 ml).

Water supply system includes the works and auxiliaries for collection, treatment, storage, and distribution of the water from the sources of supply to the free-flowing outlet of the ultimate consumer.

Source and Protection

The water supply should be obtained from the most desirable source which is feasable, and effort should be made to prevent or control pollution of the source. If the source be not adequately protected by natural means, the supply shall be adequately protected by treatment.

Frequent sanitary surveys shall be made of the water supply system to locate and identify health hazards which might exist in the system. The manner and frequency of making these surveys, and the rate at which discovered health hazards are to be removed, shall be in accordance with a program approved by the Reporting Agency and the Certifying Authority.

Approval of water supplies shall be dependent in part upon:
(a) Enforcement of rules and regulations to prevent development of health hazards;
(b) Adequate protection of the water quality throughout all parts of the system, as demonstrated by frequent surveys;
(c) Proper operation of the water supply system under the responsible charge of personnel whose qualifications are acceptable to the Reporting Agency and the Certifying Authority;
(d) Adequate capacity to meet peak demands without development of low pressures or other health hazards; and
(e) Record of laboratory examinations showing consistent compliance with the water quality requirements of these Standards.

For the purpose of application of these Standards, responsibility for the conditions in the water supply system shall be considered to be held by:
(a) The water purveyor from the source of supply to the connection to the customer's service piping; and
(b) The owner of the property served and the municipal, county, or other authority having legal jurisdiction from the point of connection to the customer's service piping to the free-flowing outlet of the ultimate consumer.

Bacteriological Quality

Sampling

Compliance with the bacteriological requirements of these Standards shall be based on examinations of samples collected at representative points throughout the distribution system. The frequency of sampling and the location of sampling points shall be established jointly by the

Reporting Agency and the Certifying Authority after investigation by either agency, or both, of the source, method of treatment, and protection of the water concerned.

The minimum number of samples to be collected from the distribution system and examined each month should be in accordance with the number on the graph in Figure 5, for the population served by the system. For the purpose of uniformity and simplicity in application, the number determined from the graph should be in accordance with the following: for a population of 25,000 and under--to the nearest 1; 25,001 to 100,000--to the nearest 5; and over 100,000--to the nearest 10.

In determining the number of samples examined monthly, the following samples may be included, provided all results are assembled and available for inspection and the laboratory methods and technical competence of the laboratory personnel are approved by the Reporting Agency and the Certifying Authority:

(a) Samples examined by the Reporting Agency.
(b) Samples examined by local government laboratories.
(c) Samples examined by the water works authority.
(d) Samples examined by commercial laboratories.

The laboratories in which these examinations are made and the methods used in making them shall be subject to inspection at any time by the designated representatives of the Certifying Authority and the Reporting Agency. Compliance with the specified procedures and the results obtained shall be used as a basis for certification of the supply.

Daily samples collected following a bacteriologically unsatisfactory sample, as provided in the following three paragraphs on "Limits " shall be considered as special samples and shall not be included in the total number of samples examined. Neither shall such special samples be used as a basis for prohibiting the supply, provided that: (1) When waters of unknown quality are being examined, simultaneous tests are made on multiple portions of a geometric series to determine a definitive coliform content; (2) Immediate and active efforts are made to locate the cause of pollution; (3) Immediate action is taken to eliminate the cause; and (4) Samples taken following such remedial action are satisfactory.

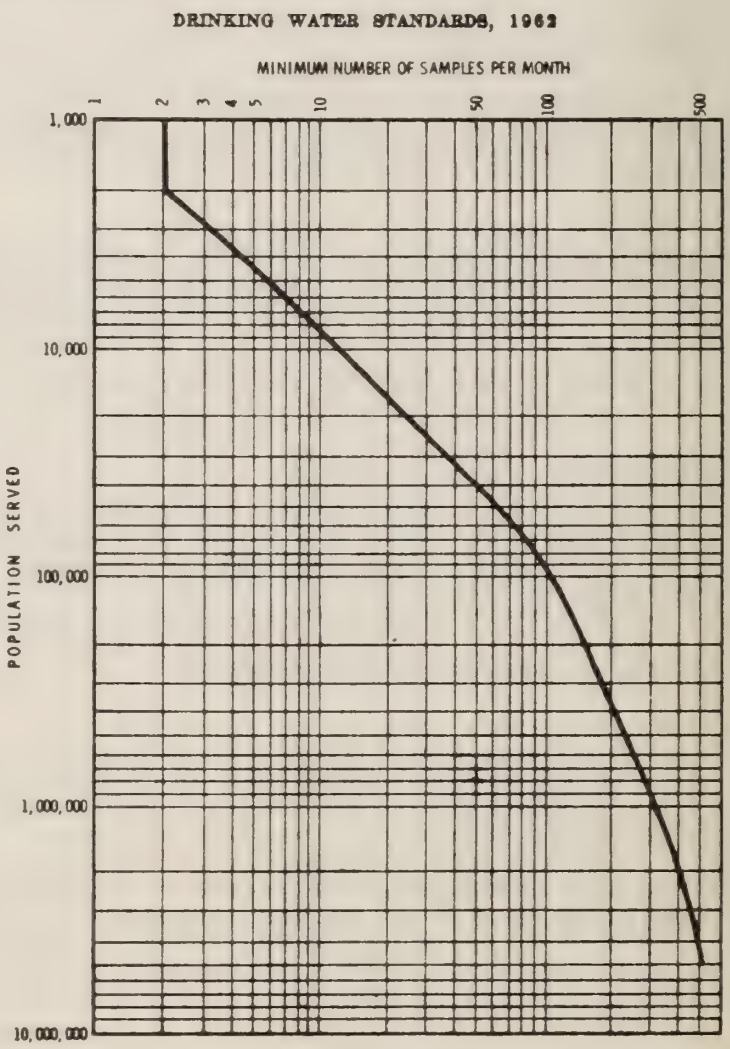


Figure 5

Limits. The presence of organisms of the coliform group as indicated by samples examined shall not exceed the following limits:

When 10 ml standard portions are examined, not more than 10 percent in any month shall show the presence of the coliform group. The presence of the coliform group in three or more 10 ml portions of a standard sample shall not be allowable if this occurs:

(a) In two consecutive samples;
(b) In more than one sample per month when less than 20 are examined permonth; or
(c) In more than 5 percent of the samples when 20 or more are examined per month.

When organisms of the coliform group occur in 3 or more of the 10 ml portions of a single standard sample, daily samples from the same sample point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

When 100 ml standard portions are examined, not more than 60 percent in any month shall show the presence of the coliform group. The presence of the coliform group in all five of the 100 ml portions of a standard sample shall not be allowable if this occurs:
(a) In two consecutive samples;
(b) In more than one sample per month when less than five are examined per month; or
(c) In more than 20% of the samples when 5 or more are examined per month.

When organisms of the coliform group occur in all five of the 100 ml portions of a single standard sample, daily samples from the same sampling points shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

When the membrane filter technique is used, the arithmetic mean coliform density of all standard samples examined per month shall not exceed one per 100 ml. Coliform colonies per standard sample shall not exceed 3/50 ml, 4/100 ml, 7/200 ml, or 13/500 ml in:
(a) Two consecutive samples;
(b) More than one standard sample when less than 20 are examined per month; or
(c) More than five percent of the standard samples when 20 or more are examined per month.

When coliform colonies in a single standard sample exceed the above values, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.

Physical Characteristics

Sampling. --The frequency and manner of sampling shall be determined by the Reporting Agency and the Certifying Authority. Under normal circumstances samples should be collected one or more times per week from representative points in the distribution system and examined for turbidity, color, threshold odor, and taste.

Limits. --Drinking water should contain no impurity which would cause offense to the sense of sight, taste, or smell. Under general use, the following limits should not be exceeded:

Turbidity----------	5 units
Color----------	15 units
Threshold Odor Number----------	3 units

Chemical Characteristics

Sampling.
The frequency and manner of sampling shall be determined by the Reporting Agency and the Certifying Authority. Under normal circumstances, analyses for substances listed below need be made only semianually. If, however, there be some presumption of unfitness because of the presence of undesirable elements, compounds, or materials, periodic determinations for the suspected toxicant or material, should be made more frequently and an exhaustive sanitary survey should be made to determine the source of the pollution. Where the concentration of a substance is not expected to increase in processing and distribution, available and acceptable source water analyses performed in accordance with standard methods may be used as evidence of compliance with these Standards.

Where experience, examination, and available evidence indicate that particular substances are consistently absent from a water supply or below levels of concern, semiannual examinations for those substances may be omitted when approved by the Reporting Agency and the Certifying Authority.

The burden of analysis may be reduced in many cases by using data from acceptable sources. Judgment concerning the quality of water supply and the need for performing specific local analyses may depend in part on information produced by such agencies as: (1) The U. S. Geological Survey, which determines chemical quality of surface and ground waters of the United States and publishes these data in "Water Supply Papers" and other reports, and (2) The U. S. Public Health Service which determines water quality related to pollution (or the absence of pollution) in the principal rivers of the Nation and publishes these data annually in "National Water Quality Network." Data on pollution of waters as measured by carbon chloroform extracts (CCE) may be found in the latter publication.

Limits. --Drinking water shall not contain impurities in concentrations which may be hazardous to the health of the consumers. It should not be excessively corrosive to the water supply system. Substances used in its treatment shall not remain in the water in concentrations greater than required by good practice. Substances which may have deleterious physiological effect, or for which physiological effects are not known, shall not be introduced into the system in a manner which would permit them to reach the consumer.

The following chemical substances should not be present in a water supply in excess of the listed concentrations where, in the judgment of the Reporting Agency and the Certifying Authority, other more suitable supplies are or can be made available.

Substance	Concentration in mg/1 liter
Alkyl Benzene Sulfonate (ABS)	0.5
Arsenic (As)	0.01
Chloride (Cl)	250.
Copper (Cu)	1.
Carbon Chloroform Extract (CCE)	0.2
Cyanide (CN)	0.01
Fluoride (F)	(See Table 6)
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate[1] (NO_3)	45.
Phenols	0.001
Sulfate (SO_4)	250.
Total Dissolved Solids	500.
Zinc (Zn)	5.

1. In areas in which the nitrate content of water is known to be in excess of the listed concentration, the public should be warned of the potential dangers of using the water for infant feeding.

The presence of the following substances in excess of the concentrations listed shall constitute grounds for rejection of the supply:

Substance	Concentration in mg/1 liter
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Hexavalent) (Cr^{6})	0.05
Cyanide (CN)	0.2
Fluoride (F)	(See Table 6)
Lead (Pb)	0.05
Selenium (Se)	0.01
Silver (Ag)	0.05

Fluoride. --When fluoride is naturally present in drinking water, the concentration should not average more than the appropriate upper limit in Table 6. Presence of fluoride in average concentrations greater than two times the optimum values in Table 6 shall constitute grounds for rejection of the supply.

Where fluoridation (supplementation of fluoride in drinking water) is practiced, the average fluoride concentration shall be kept within the upper and lower control limits in Table I.

TABLE 6.

Annual average of maximum daily air temperatures[1]	Recommended control limits-- Fluoride concentrations in mg/1 liter		
	Lower	Optimum	Upper
50.0-53.7	0.9	1.2	1.7
53.8-58.3	0.8	1.1	1.5
58.4-63.8	0.8	1.0	1.3
63.9-70.6	0.7	0.8	1.0
70.7-79.2	0.7	0.8	1.0
79.3-90.5	0.6	0.7	0.8

[1]Based on temperature data obtained for a minimum of five years.

In addition to the sampling required by paragraph on "Chemical Characteristics" above, fluoridated and defluoridated supplies shall be sampled with sufficient frequency to determine that the desired fluoride concentration is maintained.

Radioactivity

Sampling.
The frequency of sampling and analysis for radioactivity shall be determined by the Reporting Agency and the Certifying Authority after consideration of the likelihood of significant amounts being present. Where concentrations of Ra^{226} or Sr^{90} may vary considerably, quarterly samples composited over a period of three months are recommended. Samples for determination of gross activity should be taken and analyzed more frequently.

As indicated in paragraph above, data from acceptable sources may be used to indicate compliance with these requirements.

Limits
The effects of human radiation exposure are viewed as harmful and any unnecessary exposure to ionizing radiation should be avoided. Approval of water supplies containing radioactive materials shall be based upon the judgment that the radioactivity intake from such water supplies when added to that from all other sources is not likely to result in an intake greater than the radiation protection guidance[2] recommended by the Federal Radiation Council and approved by the President. Water supplies shall be approved without further consideration of other sources of radioactivity intake of Radium-226 and Strontium-90 when the water contains these substances in amounts not exceeding 3 and 10 μμc/liter, respectively. When these concentrations are exceeded, a water supply shall be approved by the certifying authority if surveillance of total intakes of radioactivity from all sources indicates that such intakes are within the limits recommended by the Federal Radiation Council for control action.

2. The Federal Radiation Council, in its Memorandum for the President, Sept. 13, 1961, recommended that "Routine control of useful applications of radiation and atomic energy should be such that expected average exposures of suitable samples of an exposed population group will not exceed the upper value of Range II (20 μμc/day of Radium-226 and 200 uuc/day of Strontium-90)."

In the known absence[3] of Strontium-90 and alpha emitters, the water supply is acceptable when the gross beta concentrations do not exceed 1,000 μμc/liter. Gross beta concentrations in excess of 1,000 μμc/liter shall be grounds for rejection of supply except when more complete analyses indicates that concentrations of nuclides are not likely to cause exposures greater than the Radiation Protection Guides as approved by the President on recommendation of the Federal Radiation Council.

Recommended Analytical Methods

Analytical methods to determine compliance with the requirements of these Standards shall be those specified in Standard Methods for the Examination of Water and Wastewater, Am. Pub. Health Assoc., current edition and those specified as follows:

Barium--Methods for the Collection and Analysis of Water Samples, Water Supply Paper No. 1454, Rainwater, F. H. and Thatcher, L. L., U.S. Geological Survey, Washington, D.C.

Carbon Chloroform Extract (CCE)--Manual for Recovery and Identification of Organic Chemicals in Water, Middleton, F. M., Rosen, A. A., and Burttschell, R. H., Robert A. Taft Sanitary Engineering Center, Public Health Service, Cincinnati, Ohio, Tentative Method for Carbon Chloroform Extract (CCE) in Water, J. Am. Water Works A. 54:223-227, Feb. 1962.

Radioactivity--Laboratory Manual of Methodology, Radionuclide Analysis of Environmental Samples, Technical Report R59-6, Robert A. Taft Sanitary Engineering Center, Public Health Service, Cincinnati, Ohio; and Methods of Radiochemical Analysis Technical Report No. 173, Report of the Joint WHO-FAO Committee, 1959, World Health Organization.

Selenium--Suggested Modified Method for Colorimetric Determination of Selenium in Natural Water, Magin, G.B., Thatcher, L. L. Rettig, S., and Levine, H., J. Am. Water Works Assoc. 52, 1199 (1960).

Organisms of the coliform group--All of the details of techniques in the determination of bacteria of this group, including the selection and preparation of apparatus and media, the collection and handling of samples and the intervals and conditions of storage allowable between collection and examination of the water sample, shall be in accordance with Standard Methods for the Examination of Water and Wastewater, current edition, and the procedures shall be those specified therein for:

The Membrane Filter Technique, Standard Test, or
The Completed Test, or
The Confirmed Test, procedure with brilliant green lactose bile broth,[4] or
The Confirmed Test, procedure with Endo or eosin methylene blue agar plates.[4]

Source and Protection of Supply

Well waters obtained from aquifers beneath impervious strata, and not connected with fragmented or cavernous rock, are usually considered sufficiently protected to preclude need for purification. However, ground waters are becoming polluted with increasing frequency and the resulting hazards require special surveillance. An illustration of such pollution is the presence of chemical pollutants originating either from sewage or industrial effluents. Surveillance of the safety of these water supplies should include chemical, physical, radiological, and biological examination.

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3. Absence is taken here to mean a negligibly small fraction of the above specific limits, where the limit for unidentified alpha emitters is taken as the listed limit for Radium-226.
4. The Confirmed Test is allowed, provided the value of this test to determine the sanitary quality of the specific water supply being examined is established beyond reasonable doubt by comparisons with Completed Tests performed on the same water supply.

Surface waters should never be used without being disinfected. Because of the increasing hazards of pollution, the use of surface waters without coagulation and filtration must be accompanied by intensive surveillance of the quality of the raw water and the disinfected supply in order to assure constant protection. This surveillance should include sanitary survey of the source and water handling, as well as biological, radiological, physical, and chemical examination of the supply.

The degree of treatment should be determined by the health hazards involved and the quality of the raw water. During times of unavoidable and excessive pollution of a source already in use, it may become necessary to provide extraordinary treatment (e.g., exceptionally strong disinfection,[1] improved coagulation, or special operation). If the pollution cannot be removed satisfactorily by treatment, use of the source should be discontinued until the pollution has been reduced or eliminated. When used, the source should be under continuous surveillance to assure adequacy of treatment in meeting the hazards of changing pollution conditions.

The adequacy of treatment should be judged, in part, upon a record of the quality of water produced by the treatment plant and the relation of this quality to the requirements of these Standards. Evaluation of adequacy of protection by treatment should also include frequent inspection of treatment works and their operation. Conscientious operation by well-trained, skillful and competent operators is an essential part of protection by treatment. Operator competency is encouraged by a formal program leading to operator certification or licensing.

Delivery of a safe water supply depends upon the protection of the water in the distribution system as well as protection of the source and by treatment. Minimum protection in the distribution system should include programs which result in the provision of sufficient and safe materials and equipment to treat and distribute the water; disinfection of water mains, storage facilities, and other equipment after each installation, repair, or other modification which may have subjected them to possible contamination; prevention of health hazards, such as cross-connections or loss of pressure because of overdraft in excess of the system's capacity; and routine analysis of water samples and frequent survey of the water supply system to evaluate the adequacy of protection. The fact that the minimum number of samples are taken and analyzed and found to comply with specific quality requirements of these Standards, is not sufficient evidence that protection has been adequate. The protection procedures and physical facilities must be reviewed along with the results of water quality analyses to evaluate the adequacy of the supply's protection. Knowledge of physical defects or of the existence of other health hazards in the water supply system is evidence of a deficiency in protection of the water supply. Even though water quality analyses have indicated that the quality requirements have been met, the deficiencies must be corrected before the supply can be considered safe.

Coliform Group

Of the two bacteriological examinations--(a) agar plate count for 24 hours at 35° C, and (b) quantitative estimation of the coliform group which have come to be recognized generally--the test for organisms of the coliform group is almost universally conceded to be the most significant. The plate count at 35° C or (20° C) incubation temperature is not required in the definition of a safe standard for potable waters but is useful as a routine quality control test in the various water treatment procedures and as a method for estimating the sanitary conditions of basins, filters, etc.

Coliform Group and Fecal Coliform Organisms as Indicators of Pollution in Drinking Water

The coliform group includes all of the aerobic and facultative anaerobic, Gram negative, nonspore-forming, rod-shaped bacilli which ferment lactose with gas (and acid) formation within 48 hours at 35° C.

1. See reference to relationship of chlorine residual and contact time required to kill viruses, in section on Microbiology.

The coliform group includes organisms that differ in biochemical and serologic characteristics and in their natural sources and habitats. Escherichia coli is characteristically an inhabitant of human and animal intestines. Aerobacter aerogenes and Aerobacter cloacae are frequently found on various types of vegetation and in materials used in joints and valves of pumps and in pipelines. The intermediate-aerogenes-cloacae (I.A.C.) subgroups may be found in fecal discharges but usually in smaller numbers than Escherichia coli. Aerobacter aerogenes and intermediate types of organisms are commonly present in soil and in waters polluted sometime in the past. Another subgroup comprises plant pathogens and other organisms of indefinite taxonomy about whose habitat information is limited. All the subgroups may be found in sewage and in polluted waters. Esch. coli is therefore frequently referred to as "fecal coli"; the I.A.C. group as "nonfecal". It must be remembered, however, that these terms are only relative.

Survival Times

Available information indicates that organisms of the Intermediate aerogenes-cloacal (I.A.C.) group tend to survive longer in water than do fecal coliform organisms. The I.A.C. group also tends to be somewhat more resistant to chlorination than Esch. coli or the commonly occurring bacterial intestinal pathogens. Because of these and other reasons, the relative survival times of the coliform subgroups may be useful in distinguishing recent from less recent pollution. In waters recently contaminated with sewage, it is expected that fecal coliform organisms will be present in numbers greater than those of the I.A.C. subgroup. But in waters that have been contaminated for a considerable length of time or have been insufficiently chlorinated, organisms of the I.A.C. subgroup may be more numerous than fecal coliform organisms.

Sanitary Significance

Information on the sanitary significance of the various types of coliform organisms is incomplete. In relation to untreated waters, however, the present position may be thus stated:

Fecal coliform organisms (Esch. coli) may be considered indicators of recent fecal pollution. No satisfactory method is currently available for differentiating fecal coliform organisms of human and animal origin. Therefore, it is necessary to consider all fecal coliform organisms as indicative of dangerous contamination.

In the absence of fecal coliform organisms, the presence of I.A.C. group organisms in untreated waters may be the result of relatively less recent fecal pollution, soil runoff water, or infrequently, fecal pollution containing only the I.A.C. group.

In general terms, the presence of fecal coliform organisms indicates recent and possibly dangerous pollution. The presence of I.A.C. organisms suggests less recent pollution or reveals the existence of defects in water treatment or distribution.

The presence of any type of coliform organisms in treated drinking water suggests either inadequate treatment or access of undesirable materials to the water after treatment. Although there are some differences between strain and subgroup organisms with regard to survival under natural conditions and resistance to chlorination, in general all the coliform organisms exhibit survival and resistance patterns in the same order of magnitude. The presence of coliform organisms (as defined earlier) in treated water calls for definitive action for their elimination.

Insofar as bacterial pathogens are concerned, the coliform group is considered a reliable indicator of the adequacy of treatment. As an indicator of pollution in drinking water supply systems, and indirectly as an indication of protection provided, the coliform group is preferred to fecal coliform organisms (Esch. coli). Whether these considerations can be extended to include rickettsial and viral organisms has not been definitely determined.

Fecal Streptococci as Indicators of Pollution

Fecal streptococci appear to be characteristic of fecal pollution, being consistently present in both the feces of all warm-blooded animals and in the environment associated with animal

discharges. They do not multiply in streams or surface waters to yield overgrowths as sometime occur with the coliform group. So far as is currently known, they are rare in soil or on vegetation not subject to continued fecal pollution. Therefore, the presence of fecal streptococci in a water indicates fecal pollution with the density equal to those originally present or reduced by natural purification processes.

By careful analysis of the streptococcal species present, the source of the fecal pollution can be estimated. For example: predominating strains of Streptococcus fecalis indicate human fecal pollution; S. bovis and S. acidominimus predominate in bovine excrement but are rarely present in human feces (about 0.4 percent of Streptococcus density); while in porcine excretal material, the species are about one-third S. fecalis (atypical types), one-third S. bovis and one-fourth S. acidominimus. Thus, it may be possible to separate human from other animal pollution and further studies of various animal excrement may permit further interpretations.

The streptococcus group in potable waters which are not chlorinated or which are in surface waters to be treated, appears to have certain advantages as indicator organisms in the interpretation of the type of pollution present. However, they do not appear to have any advantage over the coliform group in the examination of adequately chlorinated potable water.

Enteric Viruses in Water

Enteric viruses (infectious hepatitis, poliomyelitis,Coxsackie, and ECHO) should be considered as waterborne infectious agents. Epidemiological evidence indicates that treated water from a public supply is not a frequent carrier of such organisms. Clarke and Chang* have recently reviewed both the published reports on outbreaks of infectious hepatitis and poliomyelitis and laboratory evidence on the resistance of various enteric viruses.

An estimated 20,000 to 40,000 cases of infectious hepatitis were reported in Delhi, India (1955-56), attributable to treated municipal water supply. The outbreak was not accompanied by noticeable increase of typhoid fever and other intestinal diseases. This indicates that, in practice, the virus of infectious hepatitis is more resistant to chlorine (chloramine) than are vegatative bacteria. On the strength of epidemiological evidence, poliomyelitis outbreak in Edmonton, Canada was attributed to the drinking (treated) water supply. Kelly and Sanderson** showed that inactivation of enteric viruses in water at pH 7, and 25° C requires a minimum free residual chlorine of 0.3 mg/l for at least 30 minutes. At higher pH levels or lower temperatures, either more chlorine or longer contact time is required. The same authors later showed that for the same viruses in water at 25° C and a pH of 7, a concentration of at least 9 mg/l combined residual chlorine is necessary to inactivate with a contact period of 30 minutes; of 6 mg/l with a 1-hour contact time; 0.5 mg/l with a contact period of more than 7 hours.

Sabin found 10^6 TcD_{50} (dose which produces cytopathic changes in 50% of inoculated tissue cultures) of polio virus per gram of feces in human stools. Neefe et al. estimated there were 10^4 to 10^5 infectious doses of infectious hepatitis virus per gram of feces from human cases. Other estimations of viral content in feces have been in the same order of magnitude or less. Human feces normally contain 10^6 to 10^{10} coliform bacteria per gram. An estimated mean value is 10^8 coliforms per gram. Because nearly all feces contain coliform organisms and only a relatively small portion (2 to 20 percent) contribute pathogenic virus, domestic sewage normally contains approximately 10,000 times as many coliforms as virus. Virus populations in sewage and polluted waters are subject to die-aways due to aging, adsorption, sedimentation, dilution, and various undetermined causes. It is likely, therefore, that the virus content of polluted surface waters, wells, etc., is quite low when judged on the basis of the coliform-virus ratio. This relatively low virus content may account for the apparent paucity of virus infections attributed to such sources. The possibility of waterborne epidemics remains, and the efficacy of various water treatment processes including high free chlorine dosages and increased contact times should be further investigated.

*Enteric Viruses in Water, Clark, N.A., And Chang, S.L., J. Am Water Works, A. 51: 1299-1317, October 1959.

**The Effect of Chlorine in Water on Entenc Viruses, Am. J. Public Health, 48: 1323-1334, Oct. 1958; Am. J. Public Health, 50: 14-20, January 1960.

Virology techniques have not yet been developed to a point where virus enumerations can be recommended as a routine procedure in microbiological examination of drinking water.

Physical Characteristics

Plants should routinely produce water with a turbidity of less than one unit. Although turbidity, color, and odor tests do not directly measure the safety of the water, they are related to consumer acceptance of the water. The levels of 5 units of turbidity, 15 units of color, and a threshold odor number of 3 are levels at which these characteristics become objectionable to a considerable number of people. Experience has shown that under such circumstances, many people turn to alternate supplies which may be less safe.

Chemical Characteristics

In general, "grounds for rejection" limits of chemicals in water are based on the fact that the substances enumerated represent hazards to the health of man. In arriving at specific limits, the total environmental exposure of man to a stated specific toxicant has been considered. Limits are set at the lowest practical level in order to minimize the amount of a toxicant contributed by water, particularly when other sources such as milk, food, or air are known to represent the major exposure of man. The limits which are not so low as to be impracticable nor so high as to encourage pollution of water.

No attempt has been made to prescribe specific limits for every toxic or undesirable contaminant which might enter a public water supply.

Alkyl Benzene Sulfonate (Anionic Surfactant) The surfactant is a synthetic organic chemical having high residual affinity at one end of its molecule and low residual affinity at the other. Its vigorous surface activity justifies not only its name but its use as a principal ingredient of modern household detergents. Surfactants may be divided into two broad chemical classifications, ionic and non-ionic. Ionic types may be either anionic (-) or cationic (+). Alkyl benzene sulfonate is a typical anionic surfactant.

More than 75 percent of the surfactants in household detergents are of the anionic type. Alkyl aryl sulfonates account for almost three-quarters of these, the remainder being mostly alkyl sulfates. Next in extent of such use are the nonionics, the cationics making up only a small percentage. Hence, the anionic group comprises the specific materials of this type most apt to be present in raw water supplies if any at all are present. The principal agent in this anionic group is the sodium salt of the sulfonation product of dodecylbenzene, an alkyl aryl sulfonate, termed alkyl benzene sulfonate or simply ABS. It is largely for this reason that the degree of detergent contamination is established currently in terms of the concentration of alkyl benzene sulfonate (ABS), for which quantitative determination can be made by practical and reasonably satisfactory laboratory procedures.

10 percent of those using water containing less than 1 mg/l anionic sulfonated detergents have been found to complain of an off-taste, whereas all those using water containing 1.5 mg/l complained of an off-taste. Frothing was also a common complaint occurring most frequently at concentrations of 1 mg/l and above. The off-taste has been described as oily, fishy, or perfume-like. ABS itself is essentially odorless. The odor and taste characteristics are likely to rise from the degradation of products of other wastes rather than from ABS. The concentration of ABS in municipal sewage is of the order of 10 mg/l. Thus waters containing ABS are likely to be at least 10 percent of sewage origin for each mg ABS/l present.

The Toxicologic Subcommittee of the Food Protection Committee of the Food and Nutrition Board, National Research Council, published a comprehensive report in 1956 bearing on the question of surfactants in food.

In conclusion it was stated that:

(a) There are no toxic effects common to all surfactants.
(b) Surface activity per se is not a measure of toxicity.
(c) The safety of each surfactant used in food must be determined separately.

It is recommended that alkyl benzene sulfonate (ABS) in drinking water be limited to 0.5 mg/l, inasmuch as higher concentrations may cause the water to exhibit undesirable taste and foaming. Concentrations of ABS above 0.5 mg/l are also indicative of questionably undesirable levels of other sewage pollution.

An ABS concentration of 0.5 mg/l in drinking water, in terms of a daily adult human intake of 2 liters, would give a safety factor of the order of 15,000, calculated on the results tests on rats fed diets containing ABS.

Arsenic The widespread use of inorganic arsenic in insecticides and its presence in animal foods, tobacco, and other sources, make it necessary to set a limit on the concentration of arsenic in drinking water.

Normal human blood contains approximately 0.064 mg of arsenic per 100 ml, whereas urine may contain from trace amounts up to 5 mg per day. Arsenic is found in many foods in varying amounts, occurring naturally in some foods and introduced in others as in pork and turkey and appears in poultry feeds or as a pesticide spray. Shellfish and crustaceans may contain up to 170 ppm, but it is suspected that assimilation of arsenic from this source is limited. Vegetables and fruits (and wine) may contain varying small amounts. The tolerance for arsenic on sprayed fruits and vegetables set by the Food and Drug Administration is 3.5 ppm. Neither trivalent nor pentavalent arsenic is known to be an essential or beneficial element, and the body is not known to be dependent on a daily intake.

The toxicity of arsenic is well-known and the ingestion of as little as 100 mg usually results in severe poisoning. Chronic poisoning from arsenic may be insidious and pernicious. A considerable proportion is retained at low intake levels. A single dose may require ten days for complete disappearance and this slow excretion is in part the basis for its cumulative effects.

Both trivalent and pentavalent arsenic are easily absorbed from the gastrointestinal tract and lung, and become distributed throughout the body tissues and fluids. The toxicity of the pentavalent form is believed to be due to its reduction to the trivalent state. Inorganic arsenicals are potent inhibitors of the intracellular SH enzymes involved in cellular oxidations. The concentration of arsenic in kidney, liver, and the walls of the intestine can lead to serious consequences.

Recent evidence supports the view that arsenic may be carcinogenic. Industrial workers in a plant manufacturing arsenic powder were exposed to arsenic dust and showed a higher incidence of skin and lung cancer than other occupational groups.

Arsenic concentrations of from 2 to 4 mg/l are reported not to interfere with the self-purification of streams, nor have arsenic concentrations of 3 to 14 mg/l been harmful to mayfly nymphs and 10 to 20 mg/l to dragon and damsel flies. Bass have tolerated 6 mg/l for 232 hours. A concentration of 15 mg/l proved toxic to crappies and blue gills, and 20 mg/l (as sodium arsenite) proved harmful to minnows after 36 hours exposure.

The U. S. Public Health Service Drinking Water Standards for 1946 established an arsenic limit of 0.05 mg/l. In light of our present knowledge concerning the potential health hazard from the ingestion of inorganic arsenic, the concentration of arsenic in drinking water should not exceed 0.01 mg/l and concentrations in excess of 0.05 mg/l are grounds for rejection of the supply.

Barium is recognized as a general muscle stimulant, including especially the heart muscle. The fatal dose for man is considered to be from 0.8-0.9 g as the chloride (550-600 mg Ba). Most fatalities have occurred from mistaken use of barium salts incorporated in rat poison.

Aspirated barium sulfate has been reported to result in granuloma of the lung and other sites in man. Thus, evidence exists for high acute toxicity of ingested soluble barium salts, and for chronic irreversible changes in tissues resulting from the actual deposition of insoluble forms of barium in sufficient amounts at a localized site. 1 mg/l is estimated as a limit that should constitute a "no effect" level in water. Concentrations of barium in excess of 1 mg/l are grounds for rejection of the supply because of the seriousness of the toxic effects of barium on the heart, blood vessels, and nerves.

Cadmium As far as is known, cadmium is biologically a nonessential, nonbeneficial element. On the other hand, cadmium is recognized to be an element of high toxic potential. Slight cognizance has been taken of this in water quality control as evidenced by the fact that only the USSR, and in the United States, North Dakota, have set a permissible water standard for cadmium, 0.1 mg/l by the former and 0.4 mg/l as a tentative value by the latter.

The possibility of cadmium being a water contaminant has been reported in 1954; seepage of cadmium into ground water from electroplating plants has resulted in cadmium concentrations ranging from 0.01 to 3.2 mg/l. Other sources of cadmium contamination in water arise from zinc-galvanized iron in which cadmium is a contaminant.

Several instances have been reported of poisoning from eating substances contaminated with cadmium. A group of school children were made ill by eating popsicles containing 13 to 15 mg/l cadmium. A concentration of 0.01 mg/l can be tolerated over relatively long periods as evidence by being contained in drinking water having an average cadmium content of 0.047 mg/l without producing symptoms.

Carbon Chloroform Extract. Carbon Chloroform Extract (CCE) is used as a practical measure of water quality and as a safeguard against the intrusion of excessive amounts of potentially toxic material into water. It is proposed as a technically practical procedure which will afford a large measure of protection against the presence of undetected toxic materials in finished drinking water.

It is recommended that 200 micrograms CCE/l be the limiting concentrations in drinking water.

Chlorine, Sulfate, and Dissolved Solids. The importance of chloride, sulfate, and dissolved solids as they affect water quality hinges upon their taste and laxative properties.

It is recommended that limits of 250 mg/l for chloride and sulfates and 500 mg/l for total solids be set.

Waters containing more than 250 mg/l of chloride or sulfates and 500 mg/l of dissolved solids should not be used if other less mineralized supplies be available. This is influenced primarily by considerations of taste. Cathartic effects are commonly experienced with water having sulfate concentrations of 600 to 1,000 mg/l, particularly if much magnesium or sodium be present. Although waters of such quality are not generally desirable, it is recognized that a considerable number of supplies with dissolved solids in excess of the recommended limits are used without any obvious ill effects.

Chromium. The limit of 0.05 mg/l for chromium as hexavalent chromium ion appearing in the U.S. Public Health Service 1946 Drinking Water Standards was based on the lowest a - mount analytically determinable at the time it was established.

Trivalent chromium salts show none of the toxicity of the hexavalent form, particularly the highly insoluble salts. Trivalent chromium moreover, is believed not to be of concern in drinking water supplies.

Chromium is not known to be either an essential or beneficial element in the body, nor to be a common or significant element in food sources.

Copper. In the Public Health Service 1942 Drinking Water Standards, the permissible concentration of copper in drinking water was raised from 0.2 mg/l to 3.0 mg/l.

Copper is an essential and beneficial element in human metabolism, and it is well known that a deficiency in copper results in nutritional anemia in infants. The daily requirement for adults has been estimated to be 2.0 mg. The children of pre-school age require about 0.1 mg

daily for normal growth. The average daily urinary excretion is in the order of 1.0 mg, the remainder being eliminated in the feces.

Copper imparts some taste to water but individuals vary in the acuity of their taste perception and the detectable range varies from 1-5 mg/l. Small amounts are generally regarded as non-toxic but large doses may produce emesis and prolonged oral administration may result in liver damage.

Inasmuch as copper does not constitute a health hazard but imparts an undesirable taste to drinking water, it is reasonable to establish the concentration of 1.0 mg/l as the recommended limit.

Cyanide. The Public Health Service Drinking Water Standards for 1946 contain no limit for cyanide.

Because proper treatment will reduce cyanide levels to 0.01 mg/l or less, it is recommended that concentrations in water be kept below 0.01 mg CN/l.

For the protection of the health of human populations, concentrations above 0.2 mg CN/l constitute ground for rejection of the supply. This limit should provide a factor of safety of approximately 100 and is set at this level because of the rapidly fatal effect of cyanide.

Fluoride. Fluoride in drinking water will prevent dental caries. When the concentration is optimum, no ill effects will result and caries rates will be 60-65 percent below the rates in communities using water supplies with little or no fluoride.

Iron. Both iron and manganese are highly objectionable constituents in water supplies for either domestic or industrial use. The domestic consumer complains of the brownish color which iron imparts to laundered goods. Iron appreciably affects the tasteof beverages.

The taste which iron imparts to water may be described as bitter and astringent. Individuals vary in their acuity of taste perception.

Whereas the U.S. Public Health Service 1946 Drinking Water Standards set a limit of 0.3 mg/l for iron and manganese combined, it is recommended that a limit be established for each and that the concentration of iron be limited to 0.3 mg/l.

Lead. Lead taken into the body can be seriously injurious to health, even lethal, if taken in by either brief or prolonged exposure. Prolonged exposure to relatively small quantities may result in serious illness or death. Lead taken into the body in quantities in excess of certain relatively low "normal" limits is a cumulative poison.

Inasmuch as three of the four sources of lead intake in the human body -- ingested foodstuffs, inhaled atmosphere, and tobacco smoke -- are for the most part unregulated in their lead content, and because the total daily intake of lead which results in progressive retention of lead in the human body appears to be less than twice the average normal intake of lead in adults in the United States, concentrations of lead in drinking water greater than 0.05 mg/l constitute grounds for rejection of the supply.

Manganese. There are two reasons for limiting the concentration of manganese in drinking water: (a) to prevent esthetic and economic damage, and (b) to avoid any possible physiologic effects from excessive intake.

It has been reported that minute amounts of manganese cause difficulty in water quality control. The domestic consumer finds that it produces a brownish color in laundered goods and impairs the taste of beverages including coffee and tea.

From the health standpoint, there are no data to indicate at what level manganese would be harmful when ingested. The principal toxic effects which have been reported are the results of inhalation of manganese dust or fumes.

In view of the above and the difficulty of removing manganese to residual concentrations much less than 0.05 mg/l, and measuring such concentrations, manganese concentrations should be limited to a maximum of 0.05 mg/l.

Nitrate. Serious and occasionally fatal poisonings in infants have occurred following ingestion of well waters shown to contain nitrate (NO_3). This has occurred with sufficient frequency and widespread geographic distribution to compel recognition of the hazard by assigning a limit to the concentration of nitrate in drinking water.

From 1947 to 1950, 139 cases of methemoglobinemia, including 14 deaths due to nitrate in farm well-water supplies, have been reported in Minnesota alone. Wastes from chemical fertilizer plants and field fertilization may be sources of pollution. The causative factor producing blood changes in infants was first reported in 1945.

According to the methods of analysis commonly employed for nitrate in water, the presence of appreciable amounts of chloride would result in an erroneously low value for nitrate, and the presence of considerable amounts of organic matter would give an erroneously high value for nitrate. Insufficient attention has been given this important factor in evaluating permissible safe levels of nitrate in water.

Nitrate poisoning appears to be confined to infants during their first few months of life; adults drinking the same water are not affected but breast-fed infants of mothers drinking such water may be poisoned. Cows drinking water containing nitrate may produce milk sufficiently high in nitrate to result in infant poisoning. Both man and animals can be poisoned by nitrate if the concentration be sufficiently great.

Nitrite is equally dangerous in water supplies.

There are no reports of methemoglobinemia in infants fed water from public water supplies in the United States, although levels of nitrate in some may be routinely in excess of 45 mg/l. It is recommended that 10 mg nitrate nitrogen (or 45 mg nitrate) per liter of water is a limit which should not be exceeded.

At present there is no method of economically removing excessive amounts of nitrate from water. It is important, therefore, for health authorities in areas in which nitrate content of water is known to be in excess of the recommended limit to warn the population of the potential dangers of using the water for infant feeding and to inform them of alternative sources of water that may be used with safety.

Phenol. The term "phenols" is understood to include cresols and xylenols. Both the International Drinking Water Standards and those of the U. S. Public Health Service of 1946 recommended a limit of 1 µg/l of phenol in water. This limit is set because of the undesirable taste often resulting from chlorination of waters containing extremely low concentrations of phenol. Phenol concentrations of 5 mg/l or more are injurious to fish, whereas 1 mg/l or less will not seriously affect most fish. Concentrations from 15-1,000 mg/l in the drinking water were reported without observable effect on rats for extended periods; 5,000 mg/l appeared likewise to exert no effect on digestion, absorption, or metabolism, but 7,000 mg/l arrested growth and resulted in many stillbirths.

Selenium. The presence of selenium in water has heretofore been a matter of regional importance. The fact that it is now recognized as being toxic to both man and animals makes it essential that limits be set for all water intended for human consumption.

Selenium is known to produce "alkali disease" in cattle, and its effects, like those of arsenic, may be permanent. Recent reports indicate also that selenium may increase the incidence of dental caries in man. Of greater importance in limiting the concentration of selenium is its potential carcinogenicity. Rats fed a diet containing varying concentrations of selenium (3 to 40 mg/l) showed toxic effects at all levels, the outstanding pathologic lesion being hepatic cell tumors.

From very limited information, concentrations of selenium in water considered safe for man have been found toxic for fish.

In view of the potential seriousness of the reported effects, it is recommended that the limits for selenium be lowered from its present value of 0.05 mg/l to 0.01 mg/l and concentrations in excess of this lower value be used as grounds for rejection of the supply.

Silver. The need to set a water standard for silver (Ag) arises from its intentional addition to waters for disinfection. The chief effect of silver in the body is cosmetic, which consists of a permanent blue-grey discoloration of the skin, eyes, and mucous membranes which is as unsightly and disturbing to the observer as to the victim.

Because of the evidence that silver, once absorbed, is held indefinitely in tissues, particularly the skin, without evident loss through usual channels of elimination or reduction by transmigration to other body sites; and because of the probable increased absorbability of silver as silver-bound sulfur components of food cooked in silver-treated waters, the intake for which absorption was reported in 1940 to amount to 60-80 µg per day; a concentration in excess of 50 µg/l is grounds for rejection of the supply.

Zinc. Zinc is an essential and beneficial element in human metabolism. The daily requirements for preschool-age children is 0.3 mg Zn/kg. Total zinc in the adult averages 2g.

A group of individuals stationed at a depot used a drinking water supply containing zinc at 23.8 to 40.8 mg/l and experienced no known harmful effects. Communities have used waters containing from 11-27 mg/l without harmful effects. Another report stated spring water containing 50 mg/l was used for a protracted period without noticeable harm. On the other hand, another supply containing approximately 30 mg/l was claimed to cause nausea and fainting.

Zinc salts act as gastrointestinal irritants. Although the illness is acute, it is transitory.

Inasmuch as zinc in water does not cause serious effects on health but produces undesirable esthetic effects, it is recommended that concentrations of zinc be kept below 5 mg/l.

Cadmium and lead are common contaminants of zinc used in galvanizing. Assuming that zinc is dissolved from galvanized water pipe no less than cadmium, dissolution of zinc to produce 5 mg/l would be accompanied by something less than the allowable 0.01 mg cadmium per liter when cadmium contamination of the zinc is as high as 0.03 percent. Likewise, lead concentrations would likely be increased by something less than the allowable 0.05 mg/l when lead contamination of the zinc is as high as 0.6 percent.

Radioactivity

The radionuclide intake ranges recommended are the sum of radioactivity from air, food and water. Daily intakes were prescribed with the provision that dose rates be averaged over a period of one year. The range for specific radionuclides recommended by the Federal Radiation Council are found in the Chapter on Radiation Hazards.

The Advisory Committee, in considering limits which should be established for drinking water, recommended limits for only two of the above nuclides, Radium-226 (3 µµc per liter) and Strontium-90 (10 µµc per liter). Iodine-131 is not found in significant quantities in public water supplies frequently enough to call for routine monitoring and Strontium-89 levels are not likely to be significant unless Strontium-90 levels also are high.

In the case of Radium-226, above-average levels of intake generally occur only in unusual situations where the drinking water contains naturally occurring Radium-226 in greater than average amounts, as in the case of certain ground waters, or from the pollution of the supply by industrial discharges of waste containing radium. With this in mind, a limit of 3 µµc/liter has been set for Radium-226 in drinking water. If one assumes a daily intake of such drinking water of about 2 liters per day, this would result in a daily intake from water of 6 µµc which

falls in the lower portion of Range II. (See Chapter on Radiation Hazards) If there be evidence that Radium-226 from sources other than water be greater than usual, levels may have to be reduced below the above limit using the guides established by the Federal Radiation Council.

The principal source of Strontium-90 in the environment to date has been due to fallout from weapon tests, and human intake of Strontium-90 to date has been primarily from food. In recognition of this fact, the limit for Strontium-90 in water has been set at 10 μμc/liter, a limit substantially higher than the highest level found in public water supplies to date.

The Standards recognized the need to provide guidance for those situations where the limits are exceeded. In these instances, the Standards provide for the continued acceptance of the water supply if radioactivity from all other sources in addition to that from the water does not exceed intake levels recommended by the Federal Radiation Council for control action (the upper limit of Range II). It is essential in such instances for the certifying authority to determine with reasonable confidence that this latter condition is met.

In assessing the hazard of radionuclides for which limits have not been set in these Standards, or for which guidance has not yet been provided by the Federal Radiation Council, it is suggested that the values for Maximum Permissible Concentration for Water (MPCw) for the 168-hour week* of the report of the International Commission on Radiological Protection or the National Committee on Radiation Protection, adjusted by a factor appropriate for exposure of the general population, be used. When mixtures of radionuclides are present the permissible concentration of any single nuclide must be reduced by an amount determined through applicable calculations in these reports.

In these Standards an upper limit of 1,000 μμc per liter of gross beta activity (in the absence of alpha emitters and Strontium-90) has been set. If this limit be exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentrations of nuclides will not produce exposures above the recommended limits established in the Radiation Protection Guides.

The Plate Count

This technique has the following functions:
1. To determine the quantitative estimate of bacteria.
2. To separate into colonies the various types of aerobic or facultative anaerobic bacteria.

In general, the analysis consists in enumeration of the organisms or groups of organisms capable of forming colonies on a medium of nutrient agar, tryptone glucose yeast agar, milk protein hydrolysate glucose agar, or tryptone glucose agar, incubated in a dark, well ventilated incubator practically saturated with moisture at 35° C $\pm$ 0.5° C for 24 hours $\pm$ 2 hours, or at 20°C $\pm$ 0.5°C for 48 hours $\pm$ 3 hours. Different temperatures are used depending upon information desired, remembering that different groups of bacteria will grow more readily at different temperatures. Since not all the organisms in water are viable and since many viable organisms, such as those of the anaerobic and nitrifying groups, do not develop under the particular conditions which the plate count method provides, and since some of the organisms occur in groups which give rise only to a single colony, it is clear that the colony count corresponds not to the total number of organisms or even to the number of viable organisms, but only to the number of bacterial units that are able to multiply under the nutritional, respiratory and temperature conditions supplied.

The technique of plating consists in diluting 1 c.c. of water sample in 9 c.c. sterile water, giving a dilution of 1 to 10; then further diluting 1 c.c. of the 1 to 10 dilution in 9 c.c. of sterile water, giving 1 to 100 dilution; 1 c.c. of undiluted, 1 c.c. of 1 to 10 dilution, and 1 c.c. of 1 to 100 dilution are planted on separate plates and incubated. This test gives a purely quantitative estimate of the contamination. In grossly contaminated waters, greater dilutions may be made than above described. Some laboratories leave this procedure out and use lactose broth tubes

*National Bureau of Standards Handbook 69, pp. 24-91, June 5, 1959.

for estimating the coliform count from the "most probably number" table.

The Standard Tests for the Coliform Group.

The standard tests for the the coliform group consist of the presumptive test, the confirmed tests, and the completed tests.

The Presumptive Test

This technique has the function of:

1. Determining whether or not gas producing bacteria are present.
2. Determining the quantitative estimate of such bacteria.

Besides a general bacterial enumeration, an attempt is made to estimate the number of coliform bacteria in the water. The usual technique for estimating coliform bacilli is by the above described dilution method using a standard liquid lactose broth or lauryl tryptose broth medium which allows for the observation of gas production -- an important property aiding to differentiate coliform from most non-coliform bacilli.

The fermentation tubes are incubated for 24 hours. If no gas be formed, then the tube is incubated for 48 hours. Gas formation within 48 hours constitutes a positive Presumptive test.

Absence of gas in 48 hours constitutes a negative test for presence of the coliform groups of organisms in the quantity of water planted.

The results are reported either in terms such as "coliform organisms present in 10 c.c., absent from 1 c.c.", or in terms of the "most Probable Number". Since other organisms, such as certain aerobic spore-bearers, may give rise to acid and gas in lactose broth, the count is best referred to as the "presumptive coliform count".

The Confirmed Test

This technique determines whether or not acid producing bacteria are present (true fermentation produces both gas and acid, but to make certain that true fermentation has taken place when gas is found, acidity must be demonstrated.)

In this test, a selective media such as eosin methylene blue (E. M. B.) agar or Endo is used. The former has the selective action of producing round, black colonies in presence of acid from fermentation. The latter produces red colonies under such circumstances. Other indicators may be used. Liquid such as brilliant-green lactose bile broth may be used instead of solid media. These media are selective for the genera, Escherichia and Aerobacter, which are the true coliform types.

One or more such plates are streaked or brilliant green lactose bile tubes inoculated from each tube which shows gas formation in lactose. Such plates are incubated for 24 hours at 35°C. and brilliant green lactose bile tubes for 48 hours at 35°C. The presence of typical coliform colonies on the plate is a positive confirmed test.

When the liquid confirmatory medium, brilliant green bile lactose broth, is used, and gas in any amount is formed during 48 hours of incubation at 35°C, this also constitutes a positive confirmed test.

It is desirable that all lactose broth tubes showing gas at the end of 24 hours and those showing gas only at the end of 48 hours incubation be submitted to the confirmed test. If less than 3 portions of any dilution (volume), or if a series of less than three decimal dilutions of the original sample be planted, submit all tubes producing gas at 24 or 48 hours to the confirmed test. All tubes producing gas in 24 hours that have not been submitted to the confirmed test must be recorded as containing organisms of the coliform group, even though all the confirmed tests made yield negative results.

The presence of atypical colonies on the plate is a doubtful test, not to be definitely considered negative, since some coliform fail to form typical colonies, or such colonies may form slowly. Therefore it is always necessary to complete the test.

The Completed Test

This technique has the function of:

1. Re-affirming the gas producing characteristic of the bacteria.
2. Re-affirming whether or not the bacteria are aerobic or facultative anaerobic.
3. Determining whether or not the bacteria are gram negative bacilli.
4. Determining whether or not the bacteria are non-spore forming.

If the brilliant green lactose bile broth tubes used for the confirmed test be employed for the completed test, one or more Endo or eosin methyline blue plates are streaked from each tube showing gas as soon as possible after the appearance of gas. These are incubated at 35°C for 24 hours. From each of the latter plates or from each of the plates used for the confirmed test organisms are transferred from typical coliform colonies, or, when these are not present, from colonies most likely to be of the coliform group to a lactose broth fermentation tube and a nutrient agar slant. The agar slants should be incubated at 35°C for 24 hours, or 48 hours and gram-stained preparations from those corresponding to secondary lactose broth tubes that show gas should be examined microscopically.

The formation of gas in the secondary lactose broth tube and demonstration of gram-negative, nonspore forming, rod-shaped bacteria in the agar culture may be considered a satisfactory completed test. The absence of gas formation in lactose broth or failure to demonstrate gram-negative, nonspore forming bacteria constitutes a negative test.

When spore-forming organisms are found, the culture should be further studied to ascertain the possible presence of bacteria of the coliform group associated with the spore bearing organisms. This may be done by transferring the culture to formate ricinoleate broth and incubating at 35°C for 48 hours. If gas be produced, inoculate a plate and thence to lactose broth and to a nutrient agar slant from the formate ricinoleate broth. If gas be produced in lactose and no spores on the slant after 48 hours incubation, the test is completed and the presence of coliform organisms demonstrated.

The Millipore Filter, General Description

The Millipore filter, composed of pure clean inert cellulose esters, is a thin porous membrane containing millions of capillary pores of uniform dimension per square centimeter of filter surface. These pores are essentially direct channels through the filter and are evenly distributed over its surface area. Filters are available in different porosity grades ranging from 10 millimicrons to 8 microns. The size of pores in the Millipore filters is controlled to an extraordinary degree. For example, the total range of pore size distribution in the filter whose mean pore size is 0.45 microns is plus or minus 0.02 microns. One of the most significant characteristics of these filters is absolute surface retention of all particles larger than its pore size. The pores which pass through the filter occupy 80-85% of the total filter volume while the cellulose matrix, which defines the pores, occupies only 15-20%. This unique porosity characteristic permits extremely high flow rates for liquids and gases. For example, the flow of water through a filter with a mean pore size of 0.45 micron is 20 gals. per min. per sq. ft. at a pressure of 15 (psi) pounds per square inch. The Millipore filter is stable in the presence of oxygen at temperatures up to 125°C. Gradual decomposition in air takes place at temperatures above 125°C. Conversely, in oxygen free systems it may be used at temperatures up to 200°C. It is also stable at low temperatures and has been used in filtration of liquid helium at -270°C. The flash point of the Millipore filter is in excess of 200°C. It will not absorb or retain within the filter structure significant quantities of soluable components.

Sample Adequacy: Sufficient material must be sampled so that the collected contaminant will be clearly measurable at dangerous levels of contamination. Thus, 100 ml would represent an adequate sample from a high performance hydraulic system of which the contamination was measured by microscopy (particle counting); 1 to 5 gallons, a proper sample for turbine fuel to be measured gravimetrically (weight of contaminant); and a minimum of ten cubic feet for measurement of the air in a "super clean" room.

Microbiological Analysis of Water and Milk

The Millipore filter has pores small enough to prevent the passage of bacterial organisms. By filtering a sample of water or milk through the correct type of Millipore filter disc, in a

suitable filter apparatus, all bacteria present in the sample will be retained directly on the surface. Each organism thus retained may then be developed into a visible bacterial colony by super-imposing the filter on an absorbent pad saturated with a liquid nutrient medium and by incubating at approximately body temperature for 16 to 20 hours. In the presence of a differential type nutrient medium such as Endo broth, the colonies resulting from the growth of coliform bacteria will exhibit a unique characteristic golden, metallic sheen. Furthermore, a differential medium will suppress the growth of most noncoliform organisms. Thus, differentiation between coliform and noncoliform colonies is possible. All members of the coliform group will exhibit the characteristic metallic sheen.

Since each colony evident on the filter following incubation indicates the original presence of a single organism, a count of the coliform colonies on the filter will reveal the total number of coliform bacteria originally contained in the water sample. The results of the analysis are usually reported in terms of the number of coliform organisms in 100 ml. of sample.

On March 1, 1957, the U.S.P.H.S. amended its regulations to permit the official use of the membrance filter procedure in the examination of water. It is specified that the standard sample shall consist of not less than 50 milliliters. When the Millipore filter technic is used, the arithmetic mean coliform density of all standard samples examined per month shall not exceed one per 100 ml. Coliform colonies per standard sample shall not exceed 3 per 50 ml, 5 per 100 ml, and 7 per 200 ml, or 13 per 500 ml in:

a. Two consecutive samples;
b. More than one standard sample when less than 20 are examined per month; or
c. More than five percent of the standard samples when 20 or more are examined per month

The Millipore method for water analysis has been given the status of a Standard procedure in the 11th edition of Standard Methods for the Examination of Water and Waste-water, published jointly by American Public Health Association, American Water Works Association and the Water Pollution Control Federation.

U. S. Public Health Service Standard.

When examining water for evidence of conformance to the U.S. Public Health Service Drinking Water Standards, a series of 5 lactose broth fermentation tubes are inoculated, each with a 10 ml. or a 100 ml. portion of the sample. The confirmed test or the completed test must be employed for examination of these samples. The results are recorded in terms of the number of positive portions of each sample examined. For purpose of record, the results should be stated also in terms of the "most probable number" of coliform group organisms present.

The "Most Probable Number" of Coliform Bacteria".

The number of positive findings of the coliform organisms (either confirmed or completed) resulting from multiple portion decimal dilution plantings should be computed and recorded in terms of the "Most Probable Number" (M.P.N). The "Most Probable Number" is computed from a probability table*. The resulting number is only an approximation since the error of counting by the dilution method is very high.

The most desirable procedure for obtaining a single numerical value for a series of analytical results, is to express the results of each analysis in terms of its M.P.N. value and strike an arithmetic average of these values. It is mathematically incorrect to summarize the number of positive tubes in various dilutions for a number of samples from the same source on the same day or over a period of days and use an arithmetic average of the accumulated figures to determine a single M.P.N. for the series of samples.

The Coliform Indicated Number (I.N.)

In the study of raw water, polluted water, etc., it may not be desirable to determine the M.P.N., but a rough estimate may be required of the density of the coliform organisms. In

*Standard Methods for Examination of Water and Sewage, 11th. Edition, pp. 503-506.

that case, either several portions in each dilution of a single sample may be planted, or one portion in each dilution of several samples. The "indicated number" is then obtained by taking, in each decimal series, the reciprocal of the smallest positive dilution. In assembling such results, if a negative finding occurs in an amount larger than the smallest positive result, this portion is recorded as positive, and the smallest positive portion as negative.

For instance:

	1 ml	0.1 ml	0.01 ml	0.001 ml.
	+	-	+	+
Change to	+	+	+	-

The indicated number, in this case, is 100. per ml., since in this case the reciprocal of 0.01 is 100.

Results of Tests in Amounts Designated				Indicated Number of Organisms of the Coliform Group	
10 ml.	1 ml.	0.1	.01 ml.	per ml.	per 100 ml.
+	-	-	-	0.1	10.0
+	+	-	-	1.0	100.0
+	+	+	-	10.0	1000.0
+	+	+	+	100.0	10,000.0
+	+	-	+	10.0	1000.0
Total (for estimating averages)				121.1	12,110.
Average of 5 tests (adjusted to significant figures)				24.0	2,400

Too widely varying results should not be averaged. In order that results as reported may be checked and carefully evaluated, it is necessary that the report should show not only the average number of organisms per ml., but also the number of samples examined; and for each dilution, the total number of tests and the number (or per cent) positive.

Interpretation of Bacterial Analysis

Before attempting to give an opinion on the results of a bacteriological analysis, it is essential to gather particulars of the nature of the water, the methods by which it was collected, the time of collections, and the amount of recent rainfall. It is sound practice, though not always possible, for the sanitarian to make a topographical survey of the gathering ground, so as to ascertain the extent and the kind of pollution and contamination to which it is subject. If he be unable to do this personally, he should consult a map in which the source of the water and the immediate environment are indicated.

The whole aim of bacteriological analysis of water is to find evidence of excretal contamination. Since we rarely isolate directly specific pathogenic organisms such as Salmonella typhi, we resort to estimating, first of all, the probable number of living bacteria of all sorts in the water, and, secondly the probable number of living bacteria of intestinal origin. The greater the number of bacteria, the greater, presumably, is the amount of decomposing organic matter present. The more bacteria of intestinal origin there are, the more are pathogenic species likely to be amongst them. Our evidence therefore is circumstantial and is frequently open to doubt in the interpretation.

Unfortunately we cannot lay down absolute qualifications for all waters, but we can lay down a quality measure for any one water. This is possible by frequently and regularly reported examinations which teach us the range of normal variation. In this way we become acquainted with the bacterial character of the water. Any marked deviation from the normal is at once regarded with suspicion. In a water which we examine for the first time and for which we have no quality measure, it is often difficult to express more than a tentative opinion. A high agar plate count at 20°C 0.5°C, for example, may be significant or it may not; and though the sanitary survey may assist us on this point, it may not be until several examinations have been made under different conditions that we can offer a definite opinion.

The agar plate count at $20^{o}C \pm 0.5C$ gives us information on the amount of decomposing organic matter in the water available for bacterial nutrition. The more food there is, the greater is the number of organisms in the water. Most of the bacteria that develop at $20^{o}C \pm 0.5^{o}C$ are nonpathogenic to human beings, and it might therefore be thought that their number is immaterial. Generally, the greater the amount of organic matter present, the more likely is the water to be contaminated with parasitic and potentially pathogenic organisms.

The agar plate count at $35^{o}C \pm 0.5C$ is a far more important index of unsafe contamination. Most of the natural and harmless bacteria in water do not grow readily at $35^{o}C \pm 0.5^{o}C$; the organisms developing at this temperature are chiefly of sewage or intestinal origin. Hence our standards must be more stringent for colonies growing at $35^{o}C \pm 0.5^{o}C$ than at $20^{o}C \pm 0.5^{o}C$.

A high agar plate count at $35^{o}c \pm 0.5^{o}C$ is often sufficient to condemn a water, though there be a number of exceptions to this rule. For example, recently sunk wells and bores are liable for some time to give an unduly high count which later decreases as the well settles. Moreover, in some waters a rise in the agar plate count may occur in the summer months due, not to external pollution, but actual multiplication of the organisms themselves. The $35^{o}C \pm 0.5^{o}C$ agar plate count is of particular value in the control of filtration. With slow sand filters the count on the filtered water should show a 95 to 98 percent reduction from that of the raw water. A rise in the colony count is the usual signal of a defect in the filter beds, demanding instant attention.

Just as the $35^{o}C \pm 0.5^{o}C$ agar plate count is of greater significance than $20^{o} \pm 0.5^{o}C$ agar plate count, so the number of coliform bacilli is a more reliable index of excretal contamination than the $35^{o}C \pm 0.5^{o}C$ agar plate count.

Occasionally in uncontaminated deep well water, there may be a high agar count at $20^{o}C. \pm 0.5^{o}C$. This is found as a rule to result from the presence of a single species of organisms that may have gained access from the air, and multiplied abundantly. The bacteriological standards for well, spring, and cistern waters should be the same as recommended by the Public Health Service Standards.

The effect of rainfall in the water should be noted carefully. Speaking generally, the less the water is influenced by this factor, the better. Though rain in itself contains relatively few bacteria, it may carry with it large numbers of undesirable organisms from the soil. A large increase in the number of organisms, especially if attended by a rise in the coliform count, should always be regarded with suspicion.

The judgment on the potability of a water can be given only after a careful weighing of all evidence available. It must be remembered that the mere absence of evidence indicating fecal contamination does not necessarily indicate that contamination had not taken place; all it does show is that at the time the sample was examined, there was no detectable evidence of contamination. It is partly for this reason that frequent examinations are desirable.

Chapter X

Public Water Supply

No activity of the sanitarian could be more basic than the protection of water supplies used for human consumption. But the same statement can also be made in reference to the sanitary engineer. Where then does the sanitarians' work end and sanitary engineers' work begin in this phase of sanitation? This question does not have a satisfactorily precise answer because there is a wide transitional area where the work of both meet. Their work meets in such fields as public health education, inspection of water supplies, investigation and survey activities, and enforcement of sanitary regulations. It is in the highly technical engineering phases where their work separates, and yet in some of the technical aspects such as advising, consulting, and approving or disapproving plans, construction, alterations and practices relating to wells, cisterns and springs the sanitarian should be qualified to act. The sanitarian should know when to request engineering aid. But he should also know enough about the theory and practice of water supply sanitation in order to have a general understanding of the reasons why the engineer advises and performs in various ways. This chapter is therefore intended to give the sanitarian the basic information needed for his own activities and also the background information for working in concert with the sanitary engineer.

Our Supplies of Water

About 30 inches of rain, on the average, fall on the United States every year. Most of this is dissipated by evaporation, run-off into the oceans, and by the water use of plants and animals. What is left by nature averages out to 1,200 billion gallons a day, no more than half of which will be usable by man.

Today, 1960, we have 315 billion gallons a day available and a demand for water amounting to a little more than 320 billion gallons. Actually, however, there is a great imbalance between availability and need in some parts of the country and at certain times of the year.

The four potential ways for increasing the usable water supply besides capturing and storing flood waters and cleaning and reusing it are: (1) storage of water underground, (2) reduction of evaporation from reservoirs through the use of chemical films on water surfaces, (3) converting salt and brackish water into fresh water, and (4) inducing additional rainfall where needed through cloud-seeding.

Experts believe that the present supply of 315 billion gallons a day can be increased to perhaps 515 billion gallons a day by 1980 and eventually to a maximum of about 650 billion gallons.

Table 1 Past and Future Use of Fresh Water

(Billions of Gallons per Day)

	1900	1920	1940	1950	1960	1970	1980
Municipal	3.0	6.0	10.1	14.1	22.0	27.0	37.2
Industrial	15.0	27.2	52.2	84.0	159.9	218.3	394.2
Agricultural	22.2	58.4	74.1	104.6	141.0	165.9	195.7
Total	40.2	91.6	136.4	202.6	322.9	411.2	597.1

Table 2 Use of Fresh Water Vs. Estimated Dependable Supply

(Billions of Gallons per Day)

	1900	1920	1940	1950	1960	1970	1980
Rate of Use	40.2	91.6	136.4	202.7	322.9	411.2	597.1
Dependable Supply	95.0	125.0	245.0	270.0	315.0	395.0	515.0

It takes 770 gallons of water to refine a barrel (42 gallons) of petroleum, and United States refineries are now processing some eight million barrels per day. It takes 50,000 gallons to test an airplane engine; 65,000 to produce a ton of steel or a ton of paper; 200,000 to make a ton of viscose rayon; 320,000 to produce a ton of aluminum; and 600,000 gallons to make a ton of synthetic rubber. It takes more water to manufacture a square yard of nylon than it does to grow and process the equivalent amount of cotton, wool, or silk.

Table 3 Growth in Number of Water Works in the United States
1800 to 1957

Year	1800	1810	1820	1830	1840	1850	1860	1870
No. of Works	16	26	30	44	64	83	136	243
Year	1880	1890	1896	1924	1934	1939	1948	1958
No. of Works	598	1,878	3,196	9,850	10,790	12,760	16,747	20,459

Quantity

Consumption, Domestic and Industrial

1) Maximum reasonable household use including wastes due to carelessness is 50 gal. per capita per day.
   a) Physiological (subsistence) water requirement is 1.5 gal. per capita per day.
   b) Sanitary requirements are 10 to 20 gal. per capita per day.
   c) Rational household requirements (physiological, sanitary, etc.) are 30 gal. per capita per day.
2) Public requirements (washing streets, fire, etc.) are 5 to 10 gal. per capita per day.
3) Industrial requirement (average of U. S. cities) is 35 gals. per capita per day. (Ranges from 20% to 60% of total water used.)
4) Loss (due to waste and leakage in distributing lines) is 25 gal. per capita per day.

The per capita consumption of water daily in:
Small towns is 60 gallons maximum,
Small cities is 100 gallons maximum,
Large cities is 125 to 150 gallons maximum,
Rural areas is 30 to 50 gallons maximum,
United States is an average of about 120 gallons.

Type of Occupancy	Minimum quantity of water per person per day in gallons (or as indicated)
Day workers at schools and offices (per shift)	15
Hospitals (per bed)	150 to 250
Institutions other than hospitals (per bed)	75 to 125
Factories (gallons per person per shift, exclusive of industrial wastes)	15 to 35
Picnic parks (toilet usage only) (gallons per picnicker)	5
Picnic parks with bathhouses, showers and flush toilets	10
Swimming pools and bathhouses	10
Luxury residences and estates	100 to 150
Country clubs (per resident member)	100
Country clubs (per nonresident member)	25
Motels (per bed space)	40
Motels with bath, toilet, and kitchen range	50
Drive-in theaters (per car space)	5
Movie theaters (per auditorium seat)	5
Airports (per passenger)	3 to 5
Self-service laundries (gallons per wash, i.e., per customer)	50
Stores (per toilet room)	400
Service stations (per vehicle serviced)	10

Animal	Minimum daily water requirements in gallons
Horse, mule, or steer	12
Dairy cow (drinking only)	15
Dairy cow (drinking and dairy servicing)	35
Sheep	2
Hog	4
Chickens (100)	4
Turkeys (100)	7

Consumption per capita is calculated by the following formula:

$$C = \frac{D}{365 \times p}$$

C = Consumption in gallons per capita per day
D = Total number of gallons delivered into distribution system in one year
p = Total population of district served by distribution system.

Comparison of water consumption in various cities, in gallons per capita per day: Beverly Hills, 275 to 600; Chicago, 300 to 350; New York, 250 to 275; Baltimore, 125 to 135; London 50 to 55. Best places in Italy use 15 to 20 gal. per capita per day. In attempting to estimate future water consumption of a town or city we must consider the following factors: 1) Increase in population, 2) Economic status of the people, 3) the tendency in U.S. for an average increase in consumption yearly of 1 gal. per capita per day.

Type of Occupancy	Minimum quantity of water per person per day in gallons (or as indicated)
Small dwellings and cottages with seasonal occupancy	50
Single family dwellings	75
Multiple family dwellings (apartments)	60
Rooming houses	40
Boarding houses	50
Additional kitchen usage for nonresident boarders	10
Hotels without private baths	50
Hotels with private baths (2 persons per room)	60
Restaurants (toilet and kitchen usage per patron)	7 to 10
Restaurants (kitchen usage per meal served)	2-1/2 to 3
Additional for bars and cocktail lounges	2
Tourist camps or trailer parks with central bathhouse	35
Tourist camps or mobile home parks with individual bath units	50
Resort camps (night and day) with limited plumbing	50
Luxury camps	100 to 150
Work or construction camps (semipermanent)	50
Camp (with complete plumbing)	45 (Ind. w. s.)
Camp (with flush toilets -- no showers)	25 (Ind. w. s.)
Day camps (no meals served)	15
Day schools, without cafeterias, gymnasiums, or showers	15
Day schools with cafeterias, but no gymnasiums or showers	20
Day schools with cafeterias, gymnasiums and showers	25
Boarding schools	75 to 100

Public Usage

Public uses other than domestic and industrial are: Fires, cleaning streets, cleaning away ice and snow in streets, swimming pools, public drinking fountains, ornamental fountains, lakes and pools, lawn watering in parks and public places, sprinkling roads, public toilets, public buildings and laboratories, heating, etc., flushing water lines, sewers, cleaning filter beds.

General Summary of Water Supply Facilities by Population Groups and Drainage Basins, United States, 1957

Population Size Groups	Total		Ground Sources		Surface Sources		Both Ground and Surface Sources		Treated	
	Number of Facilities	Estimated Population* Served	Number of Facilities	Population Served	Number of Facilities	Population Served	Number of Facilities	Population Served	Number of Facilities	Population Served
Under 500	5,107	1,746,179	4,434	1,428,350	561	256,831	112	60,998	1,671	702,449
500 - 1,000	4,135	3,348,479	3,447	2,675,268	569	525,776	119	147,435	2,166	1,925,695
1,000 - 5,000	5,762	15,021,550	4,229	10,372,212	1,201	3,554,783	332	1,094,555	3,779	10,641,086
5,000 - 10,000	1,180	9,731,218	692	5,242,534	373	3,433,551	115	1,055,133	932	8,245,374
10,000 - 25,000	896	14,801,275	506	7,305,664	298	5,770,878	92	1,724,733	683	12,619,122
25,000 - 50,000	344	11,753,531	170	4,596,043	143	5,924,864	31	1,232,624	278	10,886,159
50,000 -100,000	183	12,395,062	77	3,565,479	90	7,591,011	16	1,238,572	149	11,796,707
Over 100,000	201	64,329,016	47	9,627,189	142	48,399,616	12	6,302,211	194	64,197,357
Major Drainage Basins										
Northeast	1,413	12,874,393	710	1,830,734	546	9,578,731	157	1,464,928	836	11,976,660
North Atlantic	1,617	27,589,624	1,128	8,822,844	349	16,690,625	140	2,076,155	1,058	26,610,060
Southeast	1,813	11,384,711	1,449	4,983,538	329	6,082,157	35	319,016	1,099	10,378,067
Tennessee River	287	1,546,352	190	441,261	79	997,611	18	107,480	252	1,520,447
Ohio River	1,911	13,090,674	1,295	4,148,156	514	8,196,617	102	745,901	1,502	12,674,814
Lake Erie	188	3,788,961	120	279,449	58	3,357,069	10	152,443	158	3,751,852
Upper Mississippi	2,188	13,803,231	2,025	4,593,266	149	8,479,120	14	730,845	1,163	12,755,770
Western Great Lakes	697	7,144,794	575	1,953,639	114	5,061,491	8	129,667	323	6,600,982
Missouri River	1,721	5,524,334	1,489	2,190,768	192	2,954,783	40	378,783	753	4,698,494
S.W. Lower Mississippi	1,614	8,106,958	1,323	4,198,832	251	3,220,686	40	687,440	983	7,342,665
Colorado River	359	1,136,796	260	698,620	84	419,180	15	18,996	156	831,043
Western Gulf	1,109	7,746,055	952	3,670,747	129	2,114,026	28	1,961,282	593	7,072,386
Pacific N.W.	952	4,009,076	622	1,308,117	251	2,243,980	79	456,979	393	3,303,475
California	1,330	12,428,522	1,047	4,687,375	184	4,531,162	99	3,209,985	368	9,068,194
Great Basin	424	1,066,269	329	477,033	61	372,073	34	217,163	113	712,608
Alaska	41	72,590	11	13,070	24	23,822	6	35,698	17	49,330
Hawaii	79	456,675	53	267,543	22	25,632	4	163,500	23	330,572
Puerto Rico	62	1,336,500	22	240,900	40	1,095,600			62	1,336,500
Virgin Islands	3	19,795	2	6,850	1	12,945				
Total	17,808	133,126,310	13,602	44,812,739	3,377	75,457,310	829	12,856,261	9,852	121,013,949

Population Size Groups	Untreated		Both Treated and Untreated		Public		Private		Both Public and Private		Not stated as to Public or Private	
	Number of Facilities	Population Served	Number of Facilities	Population Served	Number of Facilities	Population Served	Number of Facilities	Population Served	Number of Facilities	Population Served	Number of Facilities	Population Served
Under 500	3,425	1,039,090	11	4,640	3,021	1,085,333	1,871	578,319	24	9,942	191	72,585
500 - 1,000	1,958	1,414,432	11	8,352	2,888	2,423,207	1,098	801,661	25	23,936	124	99,675
1,000 - 5,000	1,963	4,333,475	20	46,989	4,434	12,064,373	1,188	2,646,141	36	86,795	104	224,241
5,000 - 10,000	242	1,440,927	6	44,917	947	8,047,252	200	1,445,043	8	45,322	25	193,601
10,000 - 25,000	205	1,949,102	8	233,051	699	12,241,233	174	2,210,873	8	105,000	15	244,169
25,000 - 50,000	64	788,372	2	79,000	249	9,413,519	88	2,172,154	2	57,358	5	110,500
50,000 -100,000	33	520,955			138	9,506,411	45	2,888,651				
Over 100,000	7	131,659			152	56,195,021	45	7,624,455			4	509,540
Major Drainage Basins												
Northeast	567	811,810	10	85,923	879	10,854,409	482	1,861,991	10	50,713	43	115,817
North Atlantic	549	952,852	10	26,712	785	20,423,989	767	6,840,653	17	69,295	48	255,687
Southeast	704	930,354	10	76,290	1,216	10,543,676	524	732,414	8	12,025	65	96,596
Tennessee River	35	25,875			200	1,138,058	77	385,844			10	22,450
Ohio River	406	381,860	3	34,000	1,135	9,519,959	695	3,425,755	14	64,526	67	80,434
Lake Erie	30	37,109			166	3,470,327	15	93,323			8	225,917
Upper Mississippi	1,025	1,047,461			1,958	12,141,569	187	1,576,526	4	1,371	39	83,765
Western Great Lakes	373	539,512	1	4,300	523	6,739,865	156	326,369	3	19,653	15	58,907
Missouri River	964	822,450	4	3,390	1,602	5,004,918	76	473,806	5	20,300	38	25,310
S.W. Lower Mississippi	630	763,793	1	500	1,311	7,031,410	257	811,323	14	50,112	32	214,113
Colorado River	203	305,753			202	907,241	142	208,812	4	6,105	10	6,101
Western Gulf	515	645,069	1	28,600	767	7,347,077	317	379,812	5	5,615	19	12,945
Pacific N.W.	552	700,997	7	4,604	669	3,570,862	249	354,384	13	17,868	21	65,962
California	953	3,141,498	8	141,430	736	9,705,708	563	2,616,771	2	1,700	29	104,343
Great Basin	309	349,461	2	4,200	252	801,658	156	228,527	3	5,270	13	30,814
Alaska	23	16,260	1	7,000	27	60,715	11	11,330			3	545
Hawaii	56	126,103			37	384,713	35	39,657	1	3,800	6	28,505
Puerto Rico					60	1,310,400					2	26,100
Virgin Islands	3	19,795			3	19,795						
Total	7,897	11,618,012	58	416,949	12,528	110,976,349	4,709	20,367,297	103	328,353	468	1,454,311

*Based on 1950 Census

Table 4

Fire Protection Bureau Requirements for Storage and Flow

Population	Flow	Period
1,000	1,000 G. P. M. *	4 hrs.
1,500	1,250 "	5 "
2,000	1,500 "	6 "
3,000	1,750 "	7 "
4,000	2,000 "	8 "
5,000	2,250 "	9 "
6,000	2,500 "	10 "
10,000	3,000 "	10 "
13,000	3,500 "	10 "
17,000	4,000 "	10 "
22,000	4,500 "	10 "
28,000	5,000 "	10 "
40,000	6,000 "	10 "
60,000	7,000 "	10 "
80,000	8,000 "	10 "
100,000	9,000 "	10 "
125,000	10,000 "	10 "
150,000	11,000 "	10 "
200,000**	12,000 "	10 "

The above fire flow can be obtained from the source of supply and storages. In determining the total storage required for the period listed, consideration must also be given to the daily city consumption in gallons per minute. For example, if a town have a 1,000 population, a well producing 200 g. p. m. and a town consumption of 100 g. p. m., the storage required would be:

Required storage = (1000 - 100) x 4 x 60 = 216,000 gallons.

The rationale of this equation: The well produces 100 gallons per minute more than the town needs. This excess water is available at all times and does not need storage. In accordance with the above table, this town would require a flow of 1000 g. p. m. for four hours. Therefore only 1000 - 100 = 900 gallons per minute have to be drawn from storage; over 4 hours or 240 minutes the total storage should be 900 x 24 = 216,000 gallons.

Reservoirs

Unless the minimum daily flow of a stream be well above the maximum daily draft which must be satisfied in a water supply project, the yield of the drainage area must be increased by the construction of an impounding reservoir. This has two functions:

1) to store up the stream flow during the winter and spring months so that it will be available in the periods of low flow.

2) to store water during normally wet years to make up for the lower flow of the dry years.

The maximum size of a reservoir is about 5% of the drainage area. The possibility of large leakage from the reservoir must be carefully considered in choosing the site. If the leakage be too great, more favorable sites must be chosen. The evaporation loss must be considered in constructing a reservoir.

Common law gives rights to use of water for down stream owners of land. This is known as riparian rights. To prevent law suits, the water rights of the stream should be bought, or a predetermined amount of water should be allowed to pass by at all times. In the arid western portion

* G. P. M. means gallons per minute

**Over 200,000 population, 12,000 G. P. M., with 2,000-8,000 G. P. M. for an additional fire.

of the United States, a new procedure, the doctrine of "prior appropriation," an outgrowth of customs established during the mining booms of the 19th century, has been established. This policy allows the economic use of the water as long as it is used for the purpose for which it was appropriated, without regarding the riparian rights as inherent. The history of the water yield of a stream or streams should be known over a long period of time (perhaps 20 years) in order to have adequate data as to the feasibility of a reservoir project.

Many dams made in construction of a reservoir are of earth. Failures of earth dams have occurred due to flows overtopping the dam and cutting it away. The quick release of the impounded water in such cases may cause heavy economic damage and loss of life. Consequently, spillways must be designed with extreme flood conditions in mind. The flood characteristics of a stream should be studied by:

1) Gauge records in the past,

2) Examination of evidence of past high stages of stream if gauges be unavailable,

3) Examination of drainage area characteristics.

Silt-bearing water may deposit so much mud in reservoirs that the accumulations will, in time, seriously impair their usefulness by decreasing the available capacity and increasing evaporation because of lesser depth of water. This occurs where soil is easily erodible and it is aggravated by deforestation or mine works. Methods of dealing with silting problems include:

1) Reforestation of hill sides in erosion areas,

2) Construction of small soil saving dams in gullies.

3) Wasting or by-passing flood flows carrying much silt,

4) Suction dredging and dragline excavations,

5) Emptying reservoir in winter and removing silt with teams.

Fig. 1 Seasonal Variation in Water Consumption

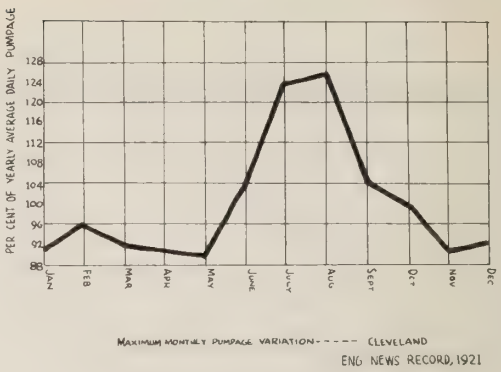


Fig. 2 Hourly Variation in Water Consumption

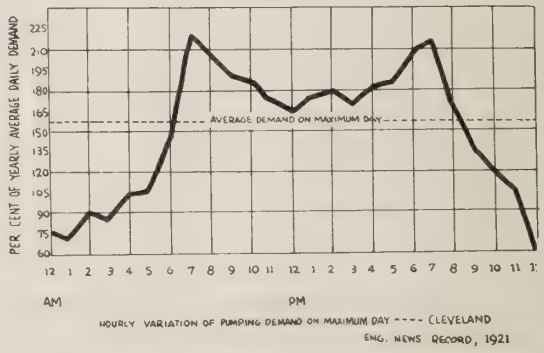
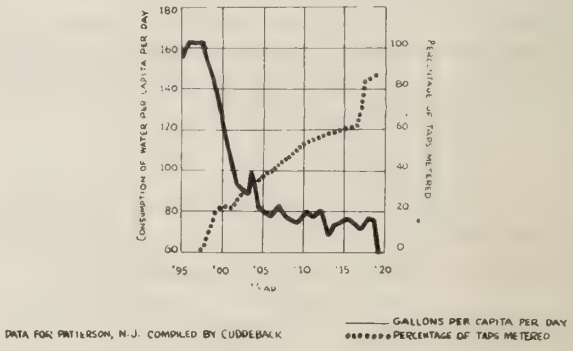


Fig. 3 The Effect of Metering Upon Water Consumption



Quality

Factors in Quality of Water.*

a) The qualities of water which are important:

1) Freedom from pathogenic microorganisms.

2) Freedom from chemical impurities affecting appearance, taste, odor, hardness or softness.

3) Freedom from algae which are likely to cause taste, odors, or toxins.

4) Optimum content in minerals which are important in relation to deficiency diseases, such as iodine and fluorine.

5) Optimum content in minerals other than those related to deficiency diseases, such as produce poisoning.

6) Optimum relation of those factors which prevent corrosion of water pipes and deterioration of water system.

b) Water Quality Depends on:

1) Origin and source (location, geology, population or watershed.)

2) Treatment process of water and natural purifying agents.

3) Distribution system.

*Thermal Pollution of Waters. Production of radioactive materials and the operation of nuclear power plants require large amounts of water for cooling. The discharge of these cooling waters is expected to raise the temperatures of the receiving waters to levels harmful to fish and shell-fish and eventually, if not controlled, to industrial and other uses. Such pollution must eventually be controlled.

c) The final product should have the following qualifications in order to assure potability:

1) Bacterial content should be such as to conform with the requirements of the U. S. P.H.S. Drinking Water Standards (see Chapter on Quality of Drinking Water).

2) The physical and chemical properties should conform to the requirement of the U.S.P.H.S. Drinking Water Standards (see chapter on Quality of Drinking Water).

3) The collection, processing, and distribution of the water should be sanitary and the management of the system should be efficient.

Techniques used for treating water in order to attain the quality of purification set by the standards of potability.

1. Storage in natural lakes or impounding reservoirs for obtaining satisfactory sedimentation and self purification.

2. Coagulation by chemical treatment to reduce turbidity and color.

3. Sedimentation of the coagulated floc to reduce the load on the filter bed.

4. Filtration thru sand and gravel beds to remove the turbidity and microorganisms.

5. Disinfection by chemical and physical agents to eliminate pathogenic bacteria.

6. Aeration, chemical treatment, or physical absorption for removal of tastes or odors.

7. Chemical treatment for reduction of hardness.

8. Alkali treatment to reduce pipe corrosion.

Treatment Techniques

A. Impounding

This method gives an even source of water to draw from during all seasons. During the period of impounding, precipitation and sedimentation of particulate matter and self-destruction of bacteria take place, and also the oxidation of unstable organic matter and the dilution of minerals by mixing of waters which are at one time high in mineral values and at another time low in mineral values. Thirty days of impounding will usually reduce the bacterial count by 95 to 98%. In instances where the only method of treatment of water is by impounding, this method alone should not be trusted. Such water should be chlorinated. High temperature, low flow, and high reservoir deficiency (decreased amount of water stored) cause an inordinate increase in the manganese content of the water. The summer heat may cause autumn surface waters to show excess manganese concentrations when impounded in deep reservoirs. This element is widely found in plants, and it is released when plants decompose. The bacterial action on organic material on a reservoir bottom at temperatures about 20° C., liberates CO_2 which combines with manganese.

The sanitation of reservoir water-sheds and reservoirs should depend on the amount of treatment given to the water. Where reservoir water is directly consumed untreated, no recreational use of reservoir should be allowed, and the use of the water-shed should be strongly discouraged. If water be chlorinated, less vigilance is necessary. Where a complete treatment plant is in use and properly operated, it would appear that the only objection of using the reservoir for bathing, fishing, etc. would be an aesthetic one. The best policy, of course, is to discourage use of reservoirs for recreation if other bodies of water be available.

B. Settling in Artificial Basins

By this method, smaller capacity reservoirs are used than by the impounding reservoir. The water here is held for 12 to 48 hours before being released for further treatment.

C. Coagulation by Chemical Treatment

Coagulating chemicals used in water purification dissociate when added to alkaline water to form a gelatinous, sticky precipitate which absorbs color producing materials and entangles mud, bacteria, and suspended matter. By agitation for 30 minutes to an hour, this gelatinous mass may be built up into flocs or clumps which are readily removed by settling. The coagulants generally used are:

1. Alum or aluminum sulphate. This is most extensively used. Maximum precipitation of alum floc varies from a pH value of 5.5 to 7.2 depending upon the mineral content of the water. Soft waters coagulate at the low pH values, while hard alkaline waters flocculate best above pH 7.0. The chemical reaction occurring in coagulation is:

$$Al_2(SO_4)_3 + 3\ Ca(HCO_3)_2 \leqslant 2Al(OH)_3 + 3\ CaSO_4 + 6CO_2$$

Often when the alkalinity is low, hydrated lime is added:

$$Al_2(SO_4)_3 + 3\ Ca(OH)_2 \leqslant 3Ca\ SO_4 + 2Al(OH)_3$$

Commercial alum is bound with 14 molecules of water: $Al_2(SO_4)_3 \cdot 14\ H_2O$

2. Ferrous Sulphate and Lime. This is low costing and effective. Ferrous sulphate may be used alone for secondary coagulation if there be sufficient oxygen in the water to insure complete oxidation. Where prechlorination is practiced, chlorine may be used for this purpose. Ferrous sulphate and lime form maximum precipitation at pH 9.0. Good results are obtained between pH 8.8 and 9.2. The chemical reaction occurring in this method of coagulation is:

$$4\ Fe\ SO_4 + 2\ Ca(HCO_3)_2 + 6\ Ca(OH)_2 + O_2 \leqslant 4\ Fe(OH)_3 + 4\ CaSO_4 + 4\ CaCO_3 + 2\ H_2O$$

3. Ferric Sulphate. Iron salts do not form soluble compounds in the alkaline range, and therefore the best precipitation occurs at around pH 9.0, although compact floc is obtained at any pH value above 3.5. The chemical reaction occurring in this method of coagulation is:

$$Fe_2(SO_4)_3 + 3Ca(HCO_3)_2 \geqslant 2Fe(OH)_3 + 3\ Ca\ SO_4 + 6\ CO_2$$

4. Chlorinated Ferrous Sulphate. The ratio is one part of chlorine to 8 parts of ferrous sulphate. About 10% excess chlorine is used to insure complete oxidation. This material has proved effective for removing certain types of color in soft waters. Results are best accomplished at pH below 7.0. Lime is added just before or after filtration to adjust the pH in order to prevent corrosion. The chemical reaction occurring in this method of coagulation is:

$$2\ Fe\ SO_4 + Cl_2 + 3Ca(HCO_3)_2 \geqslant CaCl_2 + 2CaSO_4 + 2Fe(OH)_3 + 6\ CO_2$$

5. Ferric Chloride. This has a high optimum pH zone of coagulation but can be used in low ranges for color removal. It has a great use also as a precipitant and sludge conditioner in sewage treatment. The chemical reaction occurring in this method of coagulation is:

$$2Fe\,Cl_3 + 3\,Ca\,(HCO_3)_2 \rightleftarrows 2Fe\,(OH)_3 + 3\,Ca\,Cl_2 + CO_2$$

6. Lime. This may be used as a coagulant for waters high in magnesium compounds. This is due to the magnesium hydroxide precipitated by excess of lime.

7. Sodium Aluminate. This is more expensive than other coagulants. Its application is limited. It is especially effective when used with lime and soda ash in treatment of boiler feed waters. It forms floc rapidly. The free alkali present gives it some softening properties. Unlike alum, it will not convert normal carbonates into bicarbonates.

8. Activated Alum. Alum, to which about 2% activated carbon has been added, has recently been put to use as a coagulant.

9. Activated Silica can be used for practically any kind of water to aid coagulants, such as alum or iron salts, to produce strong, absorbent, fast settling floc. Activated silica is negatively charged, and when added to water containing coagulants, the negative charges attract the positively charged substances. No dissolved silica remains in the finished water. The sodium silicate is pumped and metered by an accurate volumetric feeder.

D. Mixing, Agitation, Flocculation. (Fig. 4)

The formation of floc is obtained by agitation of the water after chemical coagulant is added. The agitation causes a clumping or coalescing of smaller colloidal particles until they become large enough to settle to the bottom. The process of coagulation is accomplished in mixing basins. The essential character of such a basin is that it be so constructed as to allow a higher initial velocity of flow, followed by a decreased speed as the water passes through it. Gentle velocities of from 0.1 foot to 1.5 feet per second are adequate:-

0.1 ft./sec. for soft colored water.
0.4 ft./sec. for hard ground water.
1.5 ft./sec. for hard surface water.

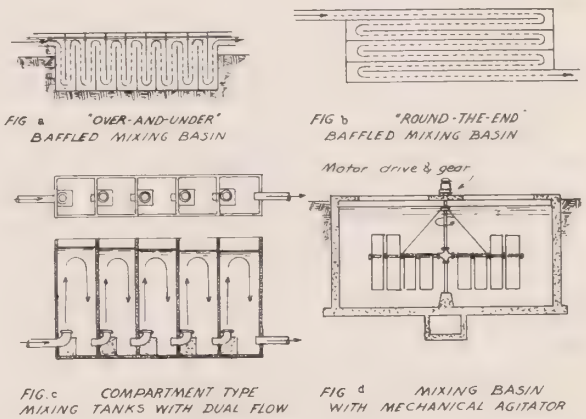


FIG a "OVER-AND-UNDER" BAFFLED MIXING BASIN
FIG b "ROUND-THE-END" BAFFLED MIXING BASIN
Motor drive & gear
FIG. c COMPARTMENT TYPE MIXING TANKS WITH DUAL FLOW
FIG d MIXING BASIN WITH MECHANICAL AGITATOR

Fig. 4. Mixing Basins for Chemical Dosage

If the water and chemicals be given a quick mix ahead of prolonged gentle agitation, the time is usually only momentary and the process extremely violent. The time of gentle agitation varies depending upon the temperature and the nature of the water treated. From 30 minutes to one hour is the usual practice.

The types of mixing devices used are baffled basins of various designs; tanks provided with rotating paddles or propellers; diffused air supplied from a compressor; and the flocculator. Properly designed baffled basins are satisfactory, but mechanical tanks are less expensive to build. They remove the rather large loss of head (2 to 3 ft.) in baffled mixing basins. Although agitators require power to keep them running, the cost of operation, if proper drive be provided, should be less than the cost of the additional lift of the water. They also provide greater accessibility and flexibility. Care should be exercised to insure uniform velocities throughout the tank.

The flocculator consists of a horizontal shaft, the length of which is at right angles to the flow of water. Paddles attached to this shaft rotate so that an outward flow is given to the upper stratum of the water being mixed, and an inward flow to the lower stratum. The inward motion causes the settled floc to be gently swept back along the bottom of the basin, lifted by the upward motion of the paddle and mixed with the incoming treated water. This introduces already precipitated floc and facilitates the coagulation process in the incoming water.

E. Sedimentation.

Sedimentation and settling mean the same, except that in water purification the word

settling is more often applied to subsidence in large natural basins, whereas subsidence in concrete basins is usually called sedimentation. In the latter case, where rapid sand filters are used in water purification, settling is aided by chemical treatment and coagulation. Such basins are also called coagulation basins and (especially in sewage treatment) chemical precipitation basins.

Sedimentation in a body of water depends on the velocity of the water, its temperature and viscosity, and the specific weight, shape, and size of the particles. For instance, particles with more weight per unity of area will settle faster than lighter ones, and particles will settle twice as fast in water of 74°F. than in water of 32°F. Experiments at New Orleans showed that it would take 2 days to settle out 50% of the suspended solids in Mississippi water (Fig. 5). For this reason coagulation is applied, and the use of sedimentation tanks is usually such that at least 75% of the suspended solids are removed in the economically least period of time.

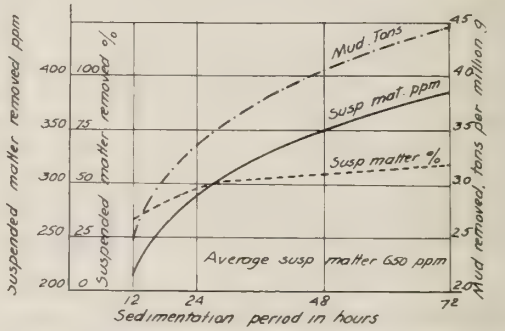


Fig. 5 Estimated Mississippi Water Subsidence at New Orleans Tests

In general the design of sedimentation tanks is based upon the following factors:

1. The character of the water, and its adaptability to flocculation as shown by laboratory tests, on which depend

2. The minimum retention period allowable (which is the total flow during a period of peak consumption in one of the summer months divided by the capacity of the basin). If, for instance, a town use five million gallons per day in July, but from 7 A. M. to 7 P. M., a period of 12 hours, the consumption be 3. 6 million, and the desired retention period be four hours, the basin should be filled 3 times during these hours and the capacity should be 3. 6÷3 or 1. 2 million gallons. The retention period should be long enough to permit a certain size particle to reach the bottom of the basin before the water reaches the outlet; in practice it is from 1. 5 to 1. 8, times this theoretical time.

3. The depth of a coagulation basin depends largely on economical conditions as excavation and construction cost. Between limits of 7 and 24 feet, 15 feet is a much used average. The length of the basin usually is between 2 to 4 times the width.

4. The flow of the water should not have a velocity exceeding 5 ft. per minute, and this velocity should be as constant as possible through any cross section of the basin. Where baffles are used, they should be of the over and under type to avoid local

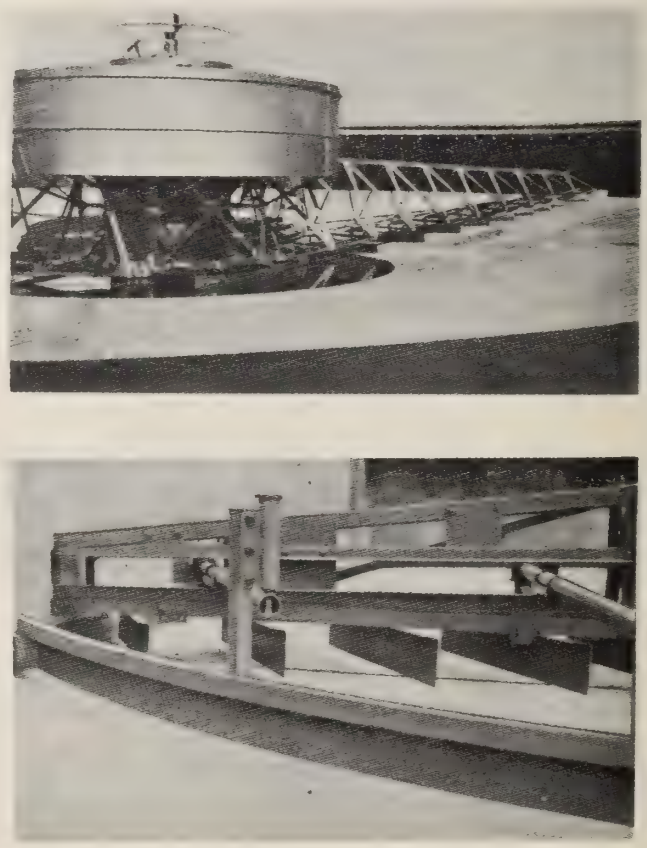


Fig. 6 Mechanical Sludge Removal
Top: View of Circular Settling Tank
Bottom: Detail of Scraper Blades
Note: See also Chapter on Sewage Disposal

variations of velocity especially near the bottom.

5. The construction of the basin should allow an efficient way of sludge removal.

The processes of coagulation and sedimentation are primary factors in efficient purification of water, since a great deal of the bacteria are removed in this way before reaching the filter beds which may be more heavily contaminated with bacteria if these be not previously removed.

Coagulation and sedimentation followed by filtration should reduce turbidity to 10 parts per million and the color to 20 ppm. or less.

The efficient removal of sludge is an important item since the accumulation of this matter:

a. Will reduce the capacity of the basin.
b. May cause tastes and odors.
c. May cause unduly long shut down periods if removal be slow.

The removal of sludge is accomplished by manual means such as flushing with a hose, or by mechanical means such as continuously revolving rakes or continuously moving belt scrapers which push or drag the sludge to a hopper outlet. (Fig. 6)

Combined Coagulation and Sedimentation Tanks. In the last few years an increasing use has been made of combined coagulation and sedimentation tanks, round and square, manufactured by various companies. As an example is taken the Accelator made by the International Filter Company (Infilco). In this tank the raw water is introduced at the top of a large centrally placed cone where it is mixed rapidly, not only with the chemicals but also with a great volume of water in an advanced stage of coagulation, by means of a rotor-impeller driven by a motor placed on top of the tank. This mixture, in which floc is built up constantly, flows over a cylindrical baffle and downward over the outside of the cone, and is recirculated after entering the cone at the bottom. The rapidly settling floc creates an annular ring of clear water which is drained off by the circular concrete trough. The surplus floc is concentrated in a "concentrator", an open tank placed between the concrete wall and the cone and occupying only 1/8 of the annular space, and from which the floc is subsequently discharged as sludge. When the operation is correct, there is a definite demarcation between the slurry and the clear water above it. This clear water is taken to the rapid sand filters. Filter runs, therefore, depend entirely on the efficiency of the accelator and on proper backwashing. (Fig. 7)

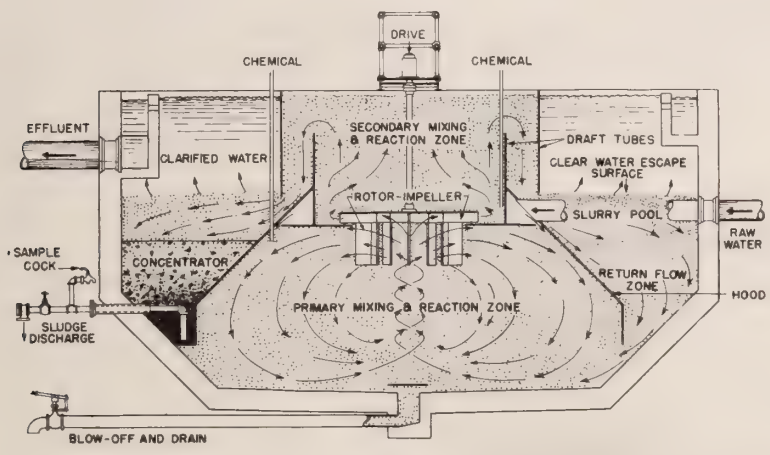


Fig. 7 Accelator

Fig. 8 Triple Cone Aerator

Flotation Method. Research by Prof. S. Hopper at the Indiana State University has demonstrated the ability of certain detergents to remove turbidity and, under proper conditions, color from water. When the detergents are mixed with the water at optimum dosage, a stream of air bubbles is introduced at the bottom of the container. These bubbles lift the impurities over the

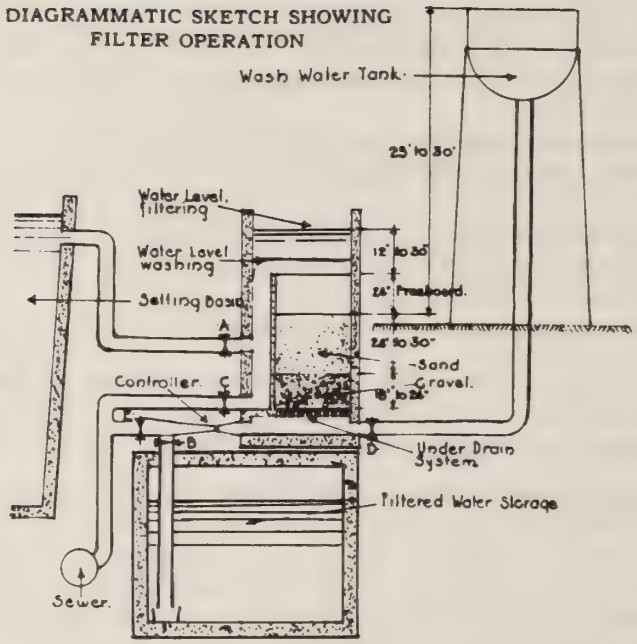


Fig. 9 Rapid Sand Filtration

Operation of Filter :

1. Open valve A : water flows from settling basin.
2. Open valve B : filtered water to storage basin. During filter operation all other valves are closed.

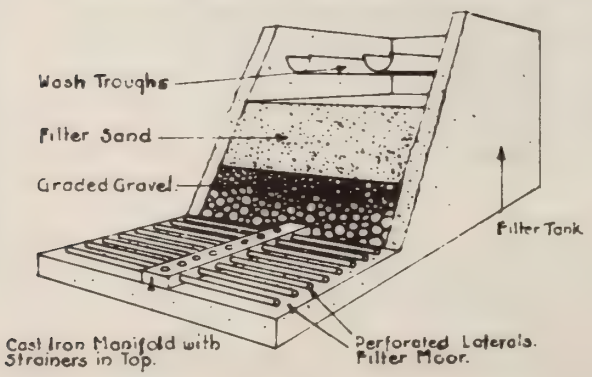
Washing of Filter :

1. Close valve A 2. Close valve B when water has reached top of troughs . 3. Open valves C and D, allowing water from tank to rise through the gravel and sand and remove the dirt on the sand to the sewer. After washing, the filter is drained to waste.

Filtration to Waste :

1. Open valves A and E, with all other valves closed, for a few minutes, after washing.

Fig. 10 Cut-away View of Gravity Filter Showing Underdrains and Filter-bed



top of the container and thereby clarify the water. This process, called Flotation Process, is based on ionization of the suspended solid particles rendering them "water repulsive." The correct detergent should be added for each kind of suspended matter. For instance, in water colored by a Bentonite clay suspension, Emulsept double bondage detergent would be indicated at a dosage of about 10 p.p.m. The method is still in the research stage.

F. Filtration

Filtration may be defined as a straining action by means of sand or other media for the removal of suspended floc and turbidity to give more complete clarification of water. There are two types of gravity filters, the slow sand filter and the rapid sand filter (Fig. 9); the first receives untreated water, the latter coagulated water and is backwashed at regular intervals. The pressure filter is a rapid sand filter in which the water is under pressure, partly to avoid additional pumps, partly to accelerate the process. The gravity filters are open and usually built of concrete; the pressure type is enclosed and built of metal. In simple terms, a filter can be described as a concrete box or basin (gravity type Fig. 10) or metal vertical or horizontal metal cylindrical tank (pressure type Fig. 11-12), provided with a strainer system at the bottom, upon which rests an 18 to 24 inch bed of graded gravel which is covered, in turn, by 24 to 30 inches of fine filter sand. Occasionally, crushed anthracite or diatomaceous earth is used. The coagulated, settled water filters down through the sand and gravel. When the filter becomes clogged (usually when the loss of head is 6 feet or over), it is washed by forcing filtered water upward through the strainer system, gravel and sand, i.e., in reverse. The sand is lifted and thoroughly agitated in the rising stream of clean water. All the finely divided and suspended matter gathered at the surface is carried away in the wash water as waste. The washing lasts from four to five minutes up to fifteen minutes, and the filter is then ready for service again. At normal rates of flow the operating period between washings varies from 20 hours to 6 days. The backwash rate is between twelve and fifteen gallons per square foot of filter surface corresponding with a rise of 20 - 24 inches per minute. Care should be taken that this flow be not suddenly applied to prevent dislodging of the gravel bed.

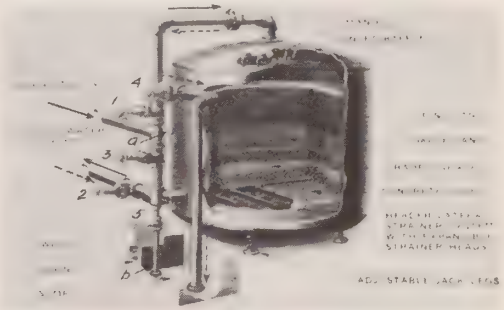


Fig. 11 Vertical Pressure Filter

Arrows indicate normal flow Dotted arrows backwash flow
a Loss of Head Indicator b Rewash drain
For use of valves see below

The filter bed usually consists of about 7 layers with the coarsest layer on the bottom and finest on top. There are usually about six layers of gravel and one of sand. Filter beds may become heavily contaminated with bacteria and cause the filtered water to show high counts. This can be overcome by pre-chlorination, i.e., chlorinating before sedimentation and filtration. The size of sand and gravel in each layer is more or less as follows:

Table 5. Sizes of Sand and Gravel in Filter Bed

Layer No.	Gravel can pass thru screen openings, in inches	Gravel is retained by screen openings, in inches	Depth of Layer, in inches
1	2 1/2	1 1/2	4
2	1 1/2	3/4	6
3	3/4	1/2	4
4	1/2	1/4	4
5	1/4	1/8	4
6	Torpedo sand 1.2 mm to 0.8 mm.		
7	Fine sand 0.38 mm. to 0.45 mm.		24-30

Filter sand is defined by its "effective size" or the size of aperture in millimeters through which 10% of the sand by weight will pass; and by the "uniformity coefficient" or the size of aperture through which 60% of the sand by weight will pass, divided by the effective size. Effective size usually is from 0.35 - 0.45 mm. for rapid sand filters, with a uniformity coefficient of 1.65 or less. For slow sand filters the effective size is 0.25 - 0.35 mm.

Loss of Head measurement is important to understand because it indicates whether or not the filter is operating efficiently. The loss of head indicates the difference between the pressure on the filter bed and the pressure in the collecting system. The difference in pressure results from the friction encountered by the water in passing through the sand, plus the head required to maintain the velocity of flow (1. 5 to 2. 5 feet.) The frictional loss in the filter aggregate may reach 10 ft. in clogged filters. This is illustrated in Fig. 13.

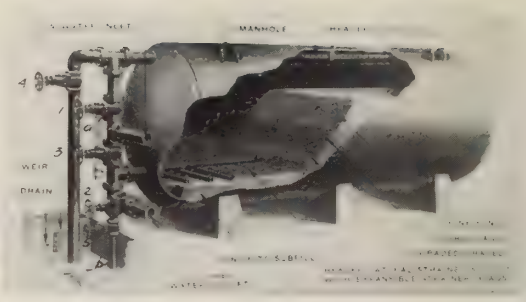


Fig. 12 Horizontal Pressure Filter

The water level in the tube A (Fig. 13. c) will always be the same as the level of water in the filter basin. The water level in Tube B (Fig. 13. c) will depend upon the pressure in the collecting system. When the filter is clean the water levels in A and B are the same, for all practical purposes. As the sand becomes clogged, it offers more resistance to water going through it and consequently the pressure in the collecting system becomes less, causing the water in tube B to drop. The difference between the levels of water in the tube A and B is called the "loss of head." When the pressure in the collecting system becomes so low that the water in tube B drops below the level of the collecting system, the filter is said to be operating under "negative" loss of head. The "loss of head" should become greater through the filter run. Any sudden decrease in "loss of head" shows a breaking or cracking of the sand bed which might permit unsatisfactorily filtered water to pass through. Loss of head may also be used to indicate when the filter needs to be washed.

Loss of Head and Rate of Flow Controllers. Efficient filtration is largely dependent upon a uniform rate of flow. Usually automatic rate of flow controllers based on venturi principle are installed which maintain a uniform flow in the filter discharge line. Loss of head indicators show the loss of head in each filter, and, with the rate of flow gauges, show when the filter has reached the condition that backwashing is necessary.

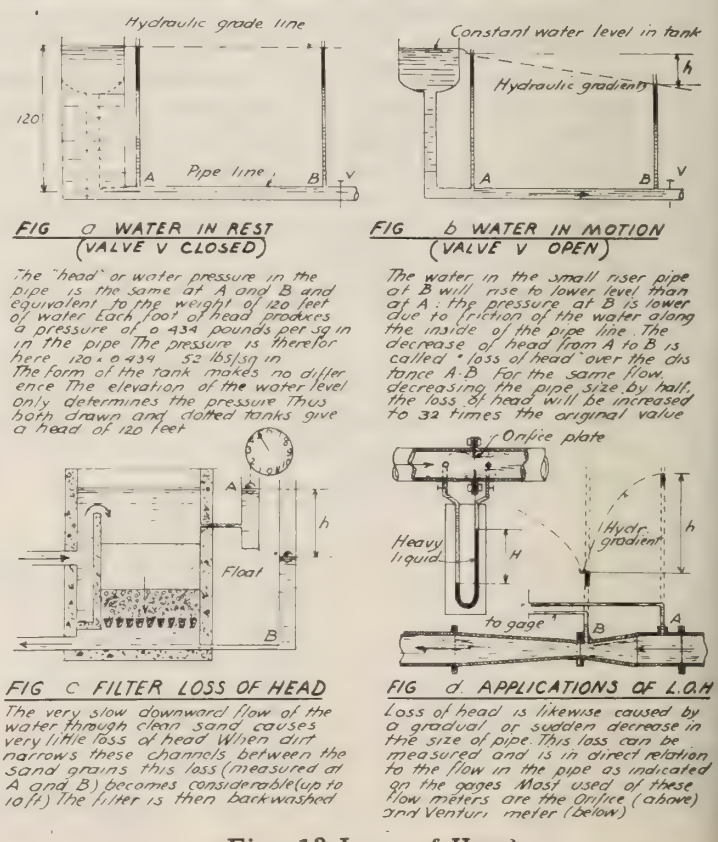

Hydraulic grade line
120'
A
Pipe line
B
V
Constant water level in tank
h
Hydraulic gradient
FIG a WATER IN REST (VALVE V CLOSED)
The "head" or water pressure in the pipe is the same at A and B and equivalent to the weight of 120 feet of water. Each foot of head produces a pressure of 0.434 pounds per sq in in the pipe The pressure is therefor here 120 × 0.434 = 52 lbs/sq in The form of the tank makes no difference The elevation of the water level only determines the pressure Thus both drawn and dotted tanks give a head of 120 feet
FIG b WATER IN MOTION (VALVE V OPEN)
The water in the small riser pipe at B will rise to lower level than at A ; the pressure at B is lower due to friction of the water along the inside of the pipe line. The decrease of head from A to B is called "loss of head" over the distance A-B For the same flow, decreasing the pipe size by half, the loss of head will be increased to 32 times the original value
Float
FIG c FILTER LOSS OF HEAD
The very slow downward flow of the water through clean sand causes very little loss of head When dirt narrows these channels between the sand grains this loss (measured at A and B) becomes considerable (up to 10 ft) The filter is then backwashed
Orifice plate
Heavy liquid
H
Hydr. gradient
to gage
FIG d APPLICATIONS OF L.O.H
Loss of head is likewise caused by a gradual or sudden decrease in the size of pipe. This loss can be measured and is in direct relation to the flow in the pipe as indicated on the gages Most used of these flow meters are the Orifice (above) and Venturi meter (below)

Fig. 13 Loss of Head

Comparison of Slow and Rapid Filters:

a) The slow filter requires less skilled operation.

b) Operating costs are generally lower with slow filter, though gallon for gallon in many instances, the cost is about equal. The rapid filter is cheap and efficient for American types of water.

c) The slow filter uses less wash water.

d) The over-all bacterial efficiencies of the two types of plants are the same.

e) The rapid filter will treat more turbid water and is more efficient in color removal.

f) The rapid filter has greater flexibility in operation because of its use of chemical pre-treatment, in the fact that there is less interruption to service while cleaning beds, and in the greater number of units.

g) Including cost of land, the rapid filter is generally lower in first cost.

h) The rapid filter is more difficult to inspect.

i) Recommended filter rates (U. S. P. H. S. Standards) are 2. 5 million gallons per acre per day (m. g. a. d.) for slow sand filters, and 2 gallons per sq. ft. per minute or 125 m. g. d. for rapid sand filters. Operating rates of existing slow sand filters vary from 5 - 15 m. g. a. d.

G. Disinfection

The most commonly used chemical for killing bacteria is chlorine. Chlorine rather easily destroys the enteric bacteria comprising the Salmonella, Shigella, and Vibrio. It also destroys a few worm parasites such as the Schistosomes. The cysts of Endameba histolytica are the most resistant to chlorine action. The usual dosage of chlorine in water does not destroy them, although they are easily eliminated by filtration. Viruses appear to be less resistant to chlorine than E. histolytica. The poliomyelitis virus has been found to become inactivated experimentally in distilled water at 21°C. to 25°C. after 1/2 hour exposure to 0.2 ppm free chlorine plus 0.2 ppm Chloramine; 0.3 ppm free chlorine plus 0.1 ppm Chloramine; and 0.35 ppm free chlorine with only traces of chloramine. The important factor to be considered in the use of chlorine is that a sufficient concentration be applied in order to give a residual content of not less than 0.2 ppm and preferably 0.4 ppm after 30 minutes contact with the water. As the bactericidal effect of chlorine decreases considerably with increasing pH of the water, these figures should be raised for waters with a high pH. The lower the temperature, the longer the contact time required. The type of chlorine usually used in a plant is liquified chlorine gas. It is more economical and effective than chlorine compounds, but has an irritating effect on the nose and throat membranes, therefore care should be exercised in handling it, i.e., a gas mask should be worn when repairs of the chlorinator are being made. A leak of chlorine can be tested with ammonia water. The chlorine will produce a dense cloud of ammonia chloride in the presence of ammonia water.

The more pollution or organic matter in the water the more chlorine it will absorb. The relationship between these two factors is embodied in the method of chlorination known as "Break-point Chlorination."

Break-point Chlorination. Breakpoint chlorination or free residual chlorination is a development in water supply treatment which has been very successful in removing objectionable tastes and odors. This method of adding high doses of chlorine to water has been named "break-point" chlorination because it was found that the residual curve "broke" and a lower residual of chlorine ensued after a certain amount of chlorine had been added to water having increased quantities of nitrogenous organic compounds.

Tastes and odors in raw waters are frequently intensified at high chlorine residuals due to the formation of nitrogen trichloride ($NC1_3$), but are greatly reduced or disappear entirely when additional chlorine is added. The delayed action is probably due to the fact that certain concentrations of pollution in water require a certain buildup in concentrations of chlorine before the oxidizing reaction takes place. This discovery led to the development of the chlorination process known as break-point chlorination.

Curve A (Fig. 14) is representative of a clear water, free from organic matter and free ammonia, in which no pronounced break-point can be obtained. Curve C is typical of water containing only slight amounts of organic material and very little free ammonia, or waters containing highly resistant organic matter. Here the break-point is not pronounced, but its presence is plainly indicated by the flat part of the curve. Curve B illustrates a definite break-point such as will be obtained with polluted waters and well waters containing appreciable amounts of free ammonia and nitrogen in other forms. The magnitude of the chlorine residual curve or its shape is seldom the same in different waters, or in the same water at different times. When waters contain varying amounts of industrial wastes, biological growths or domestic wastes, the break-point may be expected to occur at varying rates of chlorine application.

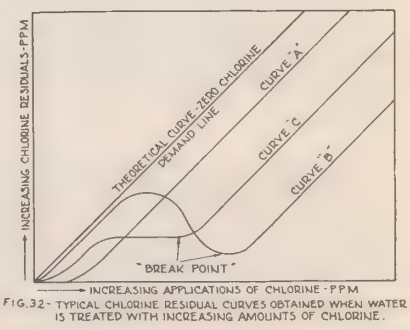


FIG. 32 - TYPICAL CHLORINE RESIDUAL CURVES OBTAINED WHEN WATER IS TREATED WITH INCREASING AMOUNTS OF CHLORINE.

Fig. 14 Break-point Chlorination

The Orthotolidine test is commonly used to measure the presence of residual chlorine in water. This test, which is a colorimetric one, has the disadvantage that, in its usual form and the usual testing apparatus, it cannot be applied on water with a higher residual than 2.0 ppm. For an accurate measurement of higher residuals, dilutions with distilled water have to be made, whereas for approximations of very high residuals, drop methods are used.

Another disadvantage is the fact that Orthotolidine not only acts on free chlorine, but also on chloramines (Chlorine-ammonia combinations), nitrites, iron salts, etc., thereby producing a "false residual." In swimming pool waters this false residual may be a considerable percentage of the measured residual unless the color be developed in the dark. For this reason, other methods and chemicals have been used to obtain the true figures for free chlorine, chloramines, and impurities.

Two methods have been successfully used in the past few years, to wit, the Orthotolidine arsenite (O. T. A.) test, and the methyl orange (M. O.) test. The first test is based upon the fact that Orthotolidine reacts within the first 15 seconds with free chlorine, and only after 30 - 40 seconds with chloramines, and the fact that sodium arsenite instantaneously prevents the action of O. T. on chlorine or chloramines in any liquid in which it is applied in the proper dosage. In the test, three tubes are filled with the water to be tested, the first and third are dosed with O. T., the second with arsenite; then after 15 seconds, the first tube receives the arsenite, the second the O. T. Consequently, only free chlorine and impurities are acted upon in the first tube. In the second tube, only the impurities; whereas in the third tube, O. T. reacts with all three ingredients. The difference in color between the first and second tubes, therefore, after three minutes contact, will give the true chlorine residual; the difference in color between the third and the second tubes, after 4 1/2 minutes, the chloramines; the second tube will give the impurities, or false residual after four minutes.

The methyl orange test is a laboratory and field method whereby an acidified sample is titrated with a high dilution of methyl orange. This will act immediately on the free chlorine only and is discolored when it reaches the liquid; if all free chlorine be used up, the liquid is turned pink. The number of cubic centimeters of diluted M. O. used is a direct measure of the free chlorine.

Chemical Disinfection

Compounds Formed with Chlorine. Compounds of chlorine with ammonia, known as chloramines, may be formed somewhat as follows:

$$\left.\begin{aligned} Cl_2 + NH_3 &\rightarrow NH_2Cl + HCl \\ HOCl + NH_3 &\rightarrow NH_2Cl + H_2O \end{aligned}\right\} = \text{monochloramine}$$

$$2Cl_2 + NH_3 \rightarrow 2HCl + NHCl_2 \quad = \text{dichloramine}$$

Chloramines are tasteless and allow much higher chlorine residual to be carried by the water without producing chlorine taste. The optimum ratio is 4 to 8 parts chlorine to one part ammonia. Chloramine requires a much longer contact with bacteria to kill them, especially at lower temperatures. Chloramines have more power to penetrate bacterial cells and cysts than chlorine alone. These compounds are more effective, for example, in killing E. histolytica. Some chloramines affecting disinfection are monochloramine (NH_2Cl), dichloramine ($NHCl_2$), nitrogen trichloride (NCl_3), halazone, and succinchloramide. The last two compounds include sulphur.

Handling Ammonia. Care must be taken in the handling of liquid ammonia, as in the handling of liquid chlorine. Liquid ammonia can be stored indefinitely. If it be kept below 80° F., there is no danger of pressure buildup in the storage cylinders. At 80° F., ammonium hydroxide contains 29.4 per cent ammonia (NH_3), with a specific gravity of 0.90. Ammonium hydroxide and liquid anhydrous ammonia must not be confused. A mixture of ammonia and air in the ratio of 1:5 is inflammable. When moist, ammonia is corrosive to metals, is highly irritating to mucous membranes, and is especially corrosive to copper and to copper-bearing alloys. Ammonia containers should be stored under conditions similar to those recommended for the storage of chlorine containers.

Nitrogen Trichloride. The possibility of the formation of nitrogen trichloride (NCl_3) when NH_4Cl is treated with excess chlorine, ($3Cl_2 + NH_4Cl \rightarrow 4HCl + NCl_3$), with resultant tastes and odors and ineffective disinfection, is a hindrance to free residual chlorination. It will occur if the pH of the water be 4.4 or less and in alkaline waters high in nitrogenous matter. Nitrogen trichloride is extremely explosive and can be removed by dechlorination with sulphur dioxide, followed by the application of the chlorine-ammonia treatment.

Dechlorination of waters with excessive amounts of chlorine can be accomplished with sodium thiosulphate ($Na_2S_2O_3$), sodium sulphite (Na_2SO_3), sodium metabisulphate ($Na_2S_2O_5$), sodium bisulphite ($NaHSO_3$), ammonia (NH_4OH), as well as with sulphur dioxide (SO_2). Some of the reactions are:

$$Na_2S_2O_3 + 3H_2O + 3Cl_2 \rightarrow Na_2SO_4 + 6HCl + SO_2$$

$$Na_2SO_3 + H_2O + Cl_2 \rightarrow Na_2SO_4 + 2HCl$$

$$SO_2 + H_2O + Cl_2 \rightarrow H_2SO_4 + 2HCl$$

The acid produced is neutralized by the alkaline compounds in the water, such as lime. Activated carbon readily absorbs chlorine from water.

Chlorine Dioxide. Chlorine dioxide is an unstable compound that is commonly generated at the point of its application by the introduction of sodium chlorite solution into the chlorinator discharge line. The resulting reaction is:

$$2NaClO_2 + Cl_2 \rightarrow 2NaCl + 2ClO_2$$

Although the theoretical ratio of chlorine to sodium chlorite is about 1:2.5, a ratio of 1:2 or less is recommended. The dose required for effective taste and odor control has varied in practice between 0.5 and 1.5 ppm. of chlorine dioxide. The chemical is most economically applied at any point after oxidation of the organic matter by chlorine. Chlorine dioxide has an oxidizing capacity 2.5 times that of chlorine, but its use as a disinfecting agent alone is not economical. It is most effective in the removal of tastes and odors, particularly against phenolic matter and algal growths, the effects being rapid. It is reported also to be more effective than chlorine as a bactericide and as a sporicide. The action is relatively unaffected by pH values between 6 and 10. This fact is important in waters of high alkalinity.

Procedure in the use of chlorine dioxide involves chlorination for disinfection followed by the application of chlorine dioxide to destroy tastes and odors. Coagulation and filtration may precede or follow chlorination and may precede the application of chlorine dioxide.

Ozone. Ozone is an unstable isotope of oxygen which, in the process of breaking down from O_3 to O_2, releases an atom of nascent oxygen. Advantages claimed for the use of ozone as a disinfectant include the following: (1) no chemical remains in the water after disinfection; (2) odors, tastes, and color are removed; and (3) cost of the process is not prohibitive. Disadvantages include the following: (1) cost is high as compared with chlorination; (2) complicated apparatus is required; (3) application is inefficient since ozone disintegrates rapidly and solubility is low, with a solubility coefficient of only 0.29 in distilled water at 14 to 15° C.; and (4) absence of residual chemical leaves no safeguard against postcontamination.

Ultraviolet Ray. The ultraviolet ray offers an effective method for the disinfection of clear water. The light kills both active bacteria and spores, which are difficult to exterminate by other means. The destructive power of light begins in the blue-green region of the spectrum with a wave length of 0.490 μ. In this connection it is interesting to note that the shortest visible violet rays have a length of 0.410 μ and the longest visible red rays have a length of 0.810 μ.

Oligodynamic Action of Metals. Certain metals, particularly silver, when immersed in water have been observed to exert an inhibiting action on bacterial life. The process is in the experimental stage, there being no installations of the type for the sterilization of a public water supply. In this process silver, with or without "activators", such as palladium or gold, is deposited on the surface of sand, porcelain, or filter candles.

Excess Lime. The "excess-lime" process involves the application of sufficient lime for softening and clarification and, in addition, sufficient lime to exert a bactericidal effect. The necessary dose is between 10 and 20 ppm. excess lime. After its bactericidal effect has been exerted, the excess lime must be removed, preferably by any one of the various methods of

recarbonation.

Iodine and Bromine. The disinfection of water with iodine and with bromine is suitable for small water supplies, swimming pools, and for individual water supplies, for example, canteen water for troops and water for travelers where properly disinfected water is unavailable. Among the advantages of these elemental substances in disinfection are the following: (1) they are effective against most forms of waterborne pathogens with 10 minutes of application at room temperature; (2) they are effective over a pH range of 3 to 8; and (3) they are less affected than is chlorine by time, temperature, impurities, and some other conditions. The substances are easier than chlorine to handle in small amounts, can be more easily packaged, and can be applied locally without the dosing equipment required for gaseous or liquid chlorine. The addition of 1 ml. of a tincture comprising 7 parts iodine, 3 parts potassium iodide, and 90 parts alcohol to 7,000 parts water with a contact period of 5 minutes has been found to give satisfactory disinfection. Iodine and bromine are available in pellet form, convenient for small doses. The dosage for disinfection should be about 8 ppm. of iodine. With either iodine or bromine, the dose should be sufficient to leave a residual of about 0.5 ppm., as determined by the standard orthotolidine test for chlorine with the values of the standards doubled.

Miscellaneous Methods of Disinfection. Water may be disinfected by the application of hydrogen peroxide (H_2O_2), by the application of ultrasonic waves in combination with small doses of disinfectants, and by other methods that are infrequently used.

Control of Viruses. Disinfecting agents and procedures that successfully destroy viruses in potable water include elemental iodine, pasteurization, heating, ozone, and chlorine dioxide. Chloramines alone are not successful as viricides. Free chlorine depends on the temperature and pH before its optimum viricidal action is realized. Poliovirus in water is inactivated by 0.3 ppm. or more of residual chlorine, but 25 ppm. may be required to kill infectious hepatitis. Normal methods of coagulation may remove 90 to 95 per cent of bacteria and viruses. Activated carbon and sand are unsatisfactory as filtering media for removing viruses.

H. Methods for Reduction or Removal of Tastes and Odors.

Tastes and odors in water may be caused by:

1) Algae and microorganisms.
2) Industrial wastes such as phenols and other oily or tarry waste products.
3) Dissolved organic solids, liquids, and gas.
4) Mineral substances, such as sodium chloride, sodium sulphate, magnesium sulphate, and iron.
5) Hydrogen sulphide.
6) Chlorine products.
7) Earthy constituents.

Methods that have been used for reducing or removing tastes and odors:

1) Aeration - for removing dissolved gases; also iron and chlorine compounds, iron, and unstable algae decomposition products by oxidation.
2) Coagulation by excess use of coagulants - may reduce or remove tastes due to earthy constituents.
3) Lime Softening - for removing taste and odor due to organic matter.
4) Superchlorination and Breakpoint chlorination - for removing tastes due to algae and organic compounds of industrial origin by oxidation. Chlorine may intensify certain tastes and odors. In some cases, especially where water contains phenol wastes, the application of chlorine dioxide, produced at point of application has been found successful.
5) Activated carbon - removes all tastes and odors by absorption except those caused by mineral matter.
6) Ammoniation: Ammonia is added with free chlorine which converts the chlorine, and whatever NCl_3 is present, into chloramine.
7) Permanganate - removes all tastes and odors by oxidation.
8) Dechlorination - by use of sulphur dioxide.
9) Various combinations of the above.

The decomposition of dead algae, diatoms, protozoa, and other microorganisms is the most common origin of tastes and odors in a water supply. Industrial wastes are probably the next most important origin. No fixed rule can be given for removing tastes and odors from a water supply. Each individual water is a problem of its own.

Algae Control.

1) The number and type of algae should be determined.

2) The algae growth curve follows the solar radiation curve, i.e., the greater the radiation the greater the growth, and vice versa. Eliminating sunlight prevents growth of algae. Therefore, algae growth will be greatly inhibited by high turbidity and color in the water.

3) Temperature is one of the important factors in determining the type of algae present and influences the numbers present. Each type of algae takes a different dosage of copper sulphate for its control. Knowing the mean temperature will more or less indicate the types of algae to expect.

4) Copper sulphate ($CuSO_4$) is most useful to control growth of algae. It is a toxic agent to algae. Dosage is 0.1 to 1 ppm. The dose depends on the type and number of algae and also on the number of fish in the water. The average dose is 0.25 to 0.3 ppm. put into the impounding reservoir. For most algae, chlorine is not as effective as copper sulphate. Larger doses than 1 ppm. produce discoloration of materials by the precipitation of the copper sulphate.

5) Chlorine prevents algae from growing and developing. Superchlorination is used to destroy taste and odor caused by algae.

For further discussion on tastes and odors in water, see Chapter IX on Quality of Drinking Water.

I. Aeration

Aeration of water has a number of useful functions. It readily removes a large percentage of hydrogen sulfide and the odors caused by decomposed organic matters. Odors caused by microscopic organisms can be greatly reduced. Simple chlorine odor can be removed, but chlorine combination odors are only slightly affected. Carbon dioxide can be removed to the extent of 70 percent or more, and corrosiveness caused by carbon dioxide will be remedied to some degree. Aeration is primarily considered as a physical or mechanical action by which undesirable matters are swept out of the water and replaced with oxygen and other gases of the air. It is also used in removal of iron and manganese, in which case the oxygen made available unites chemically to oxidize the bicarbonate and to precipitate the hydroxide of the metals. It is also used for mixing chemicals with water, as in the Aeromix process and in the use of diffused compressed air. The aeration methods used depend upon the material to be removed, efficiency desired, and local conditions as to head, etc. The various aeration methods are as follows:

1) Spray Nozzles. These are most efficient but require considerable head. They break up the water into a fine spray and will reduce carbon dioxide by 90 percent or more. They are usually operated at heads of 10 to 20 lbs. per square inch. The amount of water discharged per nozzle will depend upon nozzle design and head used. A nozzle of good design having a 1 in. orifice will discharge 72 gals. per minute to a height of 7 ft. at a 10 lb. pressure.

2) Cascades. A simple cascade consists of a flight of three or four concrete or metal steps over which the water tumbles in a thin sheet. This type is frequently used as a first step in treatment of lake and reservoir water. In summer it often is unable to reduce adequately stagnant or musty tastes and odors and those caused by algae. A more efficient cascade can be improvised for small supplies by discharging the water from a perforated pipe or box down through a series of trays or screens of 1/8 in. mesh screen cloth. The trays should be about 1.5 ft. apart. Screens can only be used in waters with low iron content.

3) Trays. Tray aeration with subsequent filtration through coke beds finds its greatest use in iron and magnesium removal plants. Plain tray aeration without contact media is also used, and has the advantage of less clogging from water of high iron content. In recent years the impinger principle in which water is discharged from a perforated pipe with force against an inverted trough placed above it, and then falling down and trickling through slat trays, has been successfully applied in Louisiana. As high as 48% removal of carbon dioxide has been achieved by the impinging effect alone, with a total removal of as high as 92% with the use of 4 slat trays.

4) Trickling Beds. These consist of beds of coke, slag or stone about 2 ft. thick supported by bronze screens. Three beds about 1.5 ft. apart are generally used. The water is applied from a perforated pipe or pipes placed above the top bed and trickles down over the coke or other material. The beds are more efficient than the cascade but less so than the sprays. Although they will remove about 75 percent of carbon dioxide when operated at about 60 gal. per minute per square foot, they are generally used for iron removal at considerably lower rates.

5) Air Diffusion. This is accomplished by blowing compressed air through porous plates in a manner similar to that used in treating sewage. The plates may be so placed as to set up a spiral flow which will mix chemicals as well as aerate. The Aeromix is a patented apparatus which employs a draft pipe through tubes. Vanes in the draft pipe also set up a spiral motion to bring the bubbles into intimate contact with the water. After leaving the draft pipe, the bubbles escape to the atmosphere. Aeration and mixing of chemicals can be combined. Both these methods will reduce hydrogen sulfide and other odors, oxidize iron and manganese, and give thorough mixing of chemicals.

6) Paddle wheel aerators are sometimes used. This type and diffused-air type are generally "after developments," added to the plant when difficulties arise.

7) Multicone Aeration. The water is discharged into the upper cone and is discharged by a large number of small orifices into the upper aspirator chamber where it is thoroughly mixed with air sucked in through annular air-inlet rings. The water is discharged from the aspirator chamber of the top cone into the water seal and air release bowl of the second cone, where the action is then repeated through second and third cones. (See Fig. 8)

J. Hardness and Alkalinity.

Hardness means that the water requires excessive amounts of soap to form a lather, or that much incrustation forms on a vessel of water which stands or is heated. This condition is due to the presence of soluble salts of the alkaline earths, especially calcium and magnesium and to a less extent, iron and aluminum which form curds with soap and cause much soap wastage. The pseudo-hardness of brines is caused by their high sodium content which prevents solution of sodium soaps.

Alkalinity of water is caused by presence of bicarbonates of calcium and magnesium, sodium and potassium, frequently by carbonates and hydroxides, and less frequently by borates, silicates and phosphates of these elements. The total alkalinity is an equilibrium mixture of the waters of hydroxide (OH), carbonate (CO_3) and bicarbonate (HCO_3) components. Alkalinity due to salts of calcium and magnesium forms part of the total hardness of water. Alkalinity due to sodium and potassium is not part of hardness of water, i.e., it does not form curds with soap. Hydroxides are not found in natural waters, but occasionally are present in treated waters.

There are two types of hardness:

1) Carbonate hardness is due to carbonates and bicarbonates of calcium, magnesium, and iron. Calcium carbonate is very slightly soluble in cold water free from CO_2, i.e., to the extent of 13 ppm. (parts per million.) Practically, $CaCO_3$ is soluble up to 35 ppm. Magnesium carbonate dissolves to the extent of 106 ppm. Most natural waters contain carbon dioxide which changes relatively insoluble carbonates to soluble bicarbonates. The boiling of water with carbonate hardness causes the carbonates to precipitate out of solution.

2) Non-carbonate hardness is usually due to sulphates, chlorides and nitrates of calcium and magnesium, iron and aluminum. These do not precipitate out of solution when the water is boiled. Negative non-carbonate hardness is due to the presence in the water of free sodium carbonate or sodium hydroxide.

Carbonate and non-carbonate hardness are expressed in terms of calcium carbonate ($CaCO_3$). The calcium carbonate equivalent of the calcium and magnesium content, sometimes with that of iron and aluminum, is a measure of the total hardness of water. Therefore all the calcium and magnesium salts (sometimes iron and aluminum) which cause hardness are reduced to $CaCO_3$. Carbonate hardness of water is reduced by the addition of hydrated lime, $Ca(OH)_2$. The amount of lime added is calculated in terms of unslaked lime, CaO. Non-carbonate hardness of water is usually reduced by the addition of soda ash, Na_2CO_3.

Relation between Alkalinity and Hardness. There is a direct relation only between calcium-magnesium alkalinity and carbonate hardness. Sodium and potassium carbonates and bicarbonates produce alkalinity but no hardness. Calcium-magnesium sulfates, nitrates and chlorides produce non-carbonate hardness, but no alkalinity.

Wherever non-carbonate hardness comes in contact with sodium alkalinity (like soda ash) it is promptly changed into carbonate hardness, and the sodium alkalinity changes into calcium alkalinity Therefore, they cannot be present at the same time; if there be sodium alkalinity, there is only carbonate hardness; and if there be non-carbonate hardness, there is no sodium alkalinity and all alkalinity is calcium alkalinity. The former can only be possible when the hardness is smaller than the alkalinity the difference between alkalinity and hardness is sodium alkalinity. The latter can only happen if the hardness be greater than the alkalinity; all alkalinity is calcium alkalinity and the difference between hardness and alkalinity is non-carbonate hardness; example

Alkalinity			Hardness		
Total	Calcium	Sodium	Total	Carbonate	Non-carbonate
80	50	30	50	50	0
80	80	0	150	80	70

The total hardness is usually measured by means of the "soap test" in which a soap solution in alcohol is added to a sample of the water until a stable lather can be produced by shaking; the amount of solution used is a direct measure of the hardness. The result is known as "soap-hardness"

The chemical reactions that take place when hydrated lime is added to hard water containing both calcium and magnesium are:

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2\,CaCO_3 + 2\,H_2O$$
$$Mg(HCO_3)_2 + Ca(OH)_2 \rightarrow MgCO_3 + CaCO_3 + 2\,H_2O$$
$$MgCO_3 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaCO_3$$
$$MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaCl_2$$
$$Mg(NO_3)_2 + Ca(OH)_2 \rightarrow Mg(OH)_2 + Ca(NO_3)_2$$
$$MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaSO_4$$

The chemical reactions that take place when soda ash is added to non-carbonate hard water, are:

$$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4$$
$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2\,NaCl$$
$$Ca(NO_3)_2 + Na_2CO_3 \rightarrow CaCO_3 + 2\,NaNO_3$$

The type of chemical reaction that occurs when hydrated lime and soda ash are added to water of non-carbonate hardness, is:

$$MgSO_4 + Ca(OH)_2 + Na_2CO_3 \rightarrow Mg(OH)_2 + CaCO_3 + Na_2SO_4$$

Both calcium carbonate and magnesium hydroxide are but little soluble and easily removed by sedimentation and filtration.

Water containing less than 50 p. p. m. of hardness may be considered soft, while that containing more than 150 p. p. m. may be considered as very hard. Drinking water with 300 p. p. m. of calcium carbonate, 1500 p. p. m. of chloride, or 2000 p. p. m. of sulfate may cause intestinal disturbances. If calcium or magnesium salts do not produce a taste in the water, a hardness of 200 p. p. m. is acceptable for domestic use. The optimum hardness, however, is about 5 grams per gallon (85. 5 p. p. m.) for softening plants. Hardness, causes incrustation of kitchen utensils, of house heating systems, of industrial steam generating plants, and directly affects the manufacture of certain food products, textile dyeing and other chemical industries.

Hardness is objectionable depending upon the geographical location, industry, and customs. Thus the water of New York has 50 p. p. m. of hardness, Baltimore has 100 p. p. m. of hardness, Indianapolis has 200 p. p. m. of hardness, Rio Grande area has 350 p. p. m. of hardness.

The economic losses due to hardness are great in terms of corrosion and interference in chemical processes of certain industries. But the economic losses to the general population from wastage of soap may also be very considerable. The following table gives an indication of this:

Table 6

Per Capita Soap Consumption with Different Types of Water

City	Total Hardness of water supply, p.p.m.	Annual per capita Soap consumption, pounds	Annual cost of soap per capita, dollars
Superior, Wis.	45	29.23	$ 3.75
Bloomington, Ill.	70	32.13	4.48
Champaign-Urbana, Ill.	298	39.89	5.93
Chicago Heights, Ill.	555	45.78	7.50

In the operation of a softening plant it is usually customary to carry caustic lime to the extent of 10 to 50 p.p.m. If two times the phenolphthalein alkalinity is less than half the methyl orange (total) alkalinity, the water contains bicarbonates and is therefore undertreated with lime.

For waters softened by a lime soda process, the total alkalinity (i.e., alkalinity to methyl orange) produced should not appreciably exceed the total hardness, which is about 35 p.p.m. (calculated as $CaCO_3$), since $CaCO_3$ is soluble to that extent. The rest of the alkalinity is composed of sodium and potassium salts.

For chemically treated waters:

1) The alkalinity to phenolphthalein (calculated as $CaCO_3$) should not be greater than 15 ppm. plus 0.4 times the total alkalinity. This requirement limits the permissible pH to about 10.0 at 25°C. for a total alkalinity not under 150 p.p.m. to avoid caustic alkalinity.

2) The normal carbonate alkalinity should not exceed 120 p.p.m. Since the normal alkalinity is a function of the hydrogen ion concentration and the total alkalinity, this requirement may be met by keeping the total alkalinity within the limits suggested below when the pH of the water is within the range given. These values apply to water at 25°C.

Table 7

pH Range:	Limits for total alkalinity (p.p.m. as $CaCO_3$)
8.0 to 9.6	400
9.7	340
9.8	300
9.9	260
10.0	230
10.1	210
10.2	190
10.3	180
10.4	170
10.5 to 10.6	160

Ion Exchange; Zeolites; Water Softening: Zeolite originally meant the naturally occurring hydrated aluminum silicates which are capable of removing cations of calcium and magnesium from hard waters in the process of softening such water. The name more recently has also been applied to anion exchange materials, and to synthetic materials, organic and inorganic, which can be used for softening water.

Because of the green color of the most commonly used natural zeolite, glauconite, it is called "greensand". Other varieties of naturally occurring zeolites have a wide variety of colors. These sand-like substances are remarkable in that they are capable of changing their composition by the ion-exchange process.

Ion exchange is the reversible exchange of ions between a liquid phase and a solid phase which is not accompanied by any radical change in the solid structure. Ion exchangers are insoluble acids or bases and consequently they are capable of reacting as ordinary acids or bases with the particular exception that one of the reaction products is removed from solution as an insoluble salt. They are classified as follows:

A. Cation-Exchange Materials
   1. Inorganic cation exchangers
      a. Processed naturally occurring minerals such as glauconites or greensands.
      b. Synthetic inorganic products such as precipitated sodium aluminosilicates.
   2. Organic cation exchangers
      a. Processed naturally occurring materials such as sulfonated coal.
      b. Synthetic resin cation exchangers
         (1) Modified phenol formaldehyde resins
         (2) Sulfonated hydrocarbons
         (3) Carboxylic acid resins
B. Anion-Exchange Materials
   1. Aromatic amine resins
   2. Aliphatic amine resins

Sodium Zeolite: This type of zeolite has sodium as a base. When water, containing calcium or magnesium salts in solution, is filtered through it, it gives up its sodium to the water and takes up a new base of calcium or magnesium. When all the sodium base of zeolite is replaced, it can no longer soften water. But sodium zeolite can be regenerated to its original composition if a strong solution of common salt (NaCl) be passed through it so that the sodium from the salt is replaced in the zeolite and the calcium or magnesium displaced from it. Salt consumption ranges between 0.37 and 0.45 pounds of salt per 1000 grains of hardness, the higher figure being the safer estimate. Chlorinated sea water can be used for this regeneration process. After that treatment, the free salt is washed out of the zeolite and it is ready again for use. The "base exchange" process was originally known as the Permutit process, because the application of this process to water softening was discovered by a German chemist named Gans who made an aritficial zeolite which he called Permutit.

The chemical reaction of the "base-or cation-exchange" process may be expressed as follows:

$$\underset{\text{(chabazite)}}{Na_2 Al_2 Si_4O_{12} \cdot 6H_2O} + Ca^{++} + SO_4 \rightarrow CaAl_2Si_4O_{12} \cdot 6H_2O + 2Na^{+} + SO_4^{--}$$

In the above equation, each molecule of insoluble sodium zeolite contains two loosely held sodium atoms. When used as filter-sand for water containing calcium sulphate ($Ca\ SO_4$), the latter ionizes into calcum (Ca^{++}) cations and sulphate (SO_4) anions. Each pair of Na^{+} cations is replaced by one Ca^{++} cation to form insoluble calcium zeolite in which each molecule contains one loosely held calcium atom. Two Na^{+} cations and one SO_4^{--} anion combine to form Na_2SO_4 in solution. If we use the symbol Z for Zeolite, then the above equation can be written:

$$Na_2Z + Ca^{++} + SO_4 \rightarrow Ca\ Z + 2Na^{++}\ SO_4^{--}$$

Calcium atoms appear to hold more tightly to zeolite than the sodium atoms. Therefore it requires approximately six times the number of calcium cations which were removed from solution by zeolite to regenerate the Na_2Z from Ca Z. This reverse equation is written as:

$$Ca\ Z + 2Na^{+} + 2Cl^{-} \rightarrow Na_2Z + Ca + 2Cl^{-}$$

Thus, calcium zeolite plus brine (Na Cl) forms sodium zeolite plus calcium chloride ($Ca\ Cl_2$). The excess brine and the calcium chloride are washed out of the filter, leaving the insoluble Na_2Z to be used again.

Zeolite filters are usually utilized in industrial water lines and are constructed similarly to sand filters, but using the zeolite material instead of sand. Some municipalities use such filters. They are effective with clear water, since turbidity particles would clog the filtering

ability of the zeolite, thus causing a loss of ion exchange power. The flow through these beds may be downward or upward depending upon plant conditions. The down flow units are operated at a rate up to six gallons per square foot per minute, and the upflow units at rates between four to eight gallons per square foot per minute.

Zeolites are rated according to the amount of grains of hardness one cubic foot can remove under plant operation conditions. Natural zeolites (greensand) averages 3000 grains, clay zeolite as high as 5500-6000 grains; certain synthetic zeolites and resins have considerably higher exchange values.

Various types of synthetic zeolites are manufactured, such as are effective in the treatment of water containing sodium salts of carbonate, bicarbonate, sulphate, and chloride, and salts of iron and manganese. Thus, sea water and water high in manganese can be softened by zeolites.

Manganese Zeolite. Due to the complexity of the chemical composition and reactions of zeolites, the exact formulations of reactions can, in many instances, not be precisely represented by equations. This is certainly the case for the equations representing the reactions of manganese zeolites. The following equations are therefore approximations. For removal of iron and manganese from drinking water, some natural zeolites have been found very efficient if care be taken that the salts of the metals remain in solution. Household filters treating water containing 10 p. p. m. of iron and 0. 3 p. p. m. of manganese produce a water practically free from these metals even with rather poor care and delayed regeneration.

Typical synthetic sodium zeolite is changed to manganous zeolite by the action of manganese chloride. The reaction is:

$$Na_2O.\ 3SiO_2.\ Al_2O_3 + MnCl_2 \rightarrow MnO.\ 3SiO_2.\ Al_2O_3 + 2NaCl$$

The manganous zeolite is then oxidized by sodium permanganate to form the higher oxides of manganese which are precipitated on the surface of the zeolite grains in accordance with the following:

$$MnO.\ 3SiO_2.\ Al_2O_3 + 2\ Na\ Mn\ O_4 \rightarrow Na_2O.\ 3SiO_2.\ Al_2O_3.\ MnO_2.\ Mn_2O_7$$

The oxides of manganese are deposited on the zeolite grains, and are available as sources of oxygen and also as a catalytic agent in the oxidation of the soluble, reduced iron and manganese compounds in the water. Manganous bicarbonate may be used to illustrate the reaction:

$$\underset{\text{(Manganese Zeolite)}}{Na_2O.\ 3SiO_2.\ Al_2O_3.\ MnO_2.\ Mn_2O_7} + \underset{\text{(Manganous bicarbonate)}}{2Mn(HCO_3)_3} \rightarrow Na_2O.\ 3SiO_2.\ Al_2O_3 + 5MnO_2 + 4CO_2 + 2H_2O$$

The oxidized manganese, MnO_2, collects in the bed until removed by back washing the bed in the usual manner. Eventually the available oxygen supply of the manganese zeolite becomes exhausted, whereupon the bed is regenerated by passing through it a solution of sodium permanganate, as before outlined.

Manganese zeolite filters using processed greensand (made of a fine grained Hornerstown glauconite) and being intermittently regenerated with sodium or potassium permanganate ($K\ Mn\ O_4$) have been successfully used since about 1920. There are a great many of these units in use today in homes, industrial plants, and municipalities. These zeolite filters are relatively costly to buy and to operate. Fine grained Hornerstown glauconite requires a low filtration rate in gallons per minute per square foot of bed area and a large size filter for a given flow rate of water. If operated at a higher rate with a greater loss of pressure, the possibilities of bed channeling and leakage of iron and impurities is great. Consequently, it is necessary to restrict the filtration rate and usually to handle waters with a total influent iron and manganese content of only about 2 or 3 parts per million. A large excess of potassium permanganate is also required to effectively regenerate this manganese zeolite.

Continuous Regeneration (CR): A few years ago a large deposit of coarser grained, almost pure Navesink glauconite mineral was economically uncovered. It was found that this raw material could be processed into a manganese zeolite with far superior properties for effectively removing iron and manganese from water. By adding potassium permanganate to the water ahead of the filter, referred to as continuous regeneration, it was found that often only about half as much potassium permanganate was required in the regeneration process. Only enough permanganate is used to give a faint pink coloration in the water at the top of the manganese zeolite bed for quickly oxidizing and precipitating the iron and manganese which is then removed by filtering through the zeolite sand. Shut-down for regeneration is no longer required since the outage time is reduced from an hour or more to only about 15 minutes. The filtration process takes place deep down in the filter bed and the filter can be operated at a much higher filtration rate without fear of channeling and leakage. The filter units are much smaller for a given flow rate. Thus, the cost of operation is much reduced.

The success of Ferrosand CR is attributable to its larger grain size and uniformity and greater grain hardness or physical resistance to attrition. With these features, the process can be operated at a higher flow or velocity and the material can be backwashed and scrubbed clean with water and air, with water and a sub-surface agitator, or with some similar system which will provide both water washing and a supplemental means of grain scrubbing to keep the grains perfectly clean at all times and exposed to a minimum of danger of grain breakage. If the grains of Ferrosand CR are kept clean, they will serve indefinitely as a catalyst for the attraction and removal of raw water iron, manganese, hydrogen sulfide and most organics.

Described in great simplicity (See Figure 15), the continuous regeneration zeolite treatment process consists of well water being pumped from the well and immediately receiving a dosage of enough potassium permanganate to give the water a slight pink coloration, then flowing directly through the filter, and coming out clear and with a very low iron and manganese content, the backwash of the accumulated deposits in the filter being disposed of simply through the backwash line. In contrast, the intermittent regeneration type of manganese zeolite process when shut-down for permanganate regenerations produces an objectionable, large excess of potassium permanganate which has to be disposed of in the local sewerage system or a nearby lake or river. Likewise, with brine regeneration using a resinous type zeolite, a large excess of salt brine waste is produced which also may present a serious disposal problem. Where pre-treatment with lime and conventional sedimentation basin are used, a large accumulation of lime sludge is produced and must be removed from the settling unit either into a local stream or lake or into nearby sludge beds for subsequent disposition, frequently presenting waste disposal problems of moderate to severe importance.

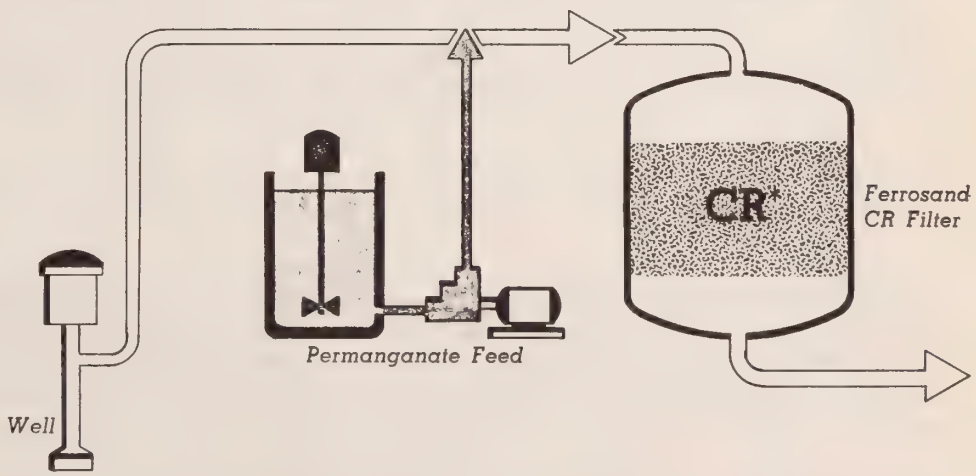


Fig. 15 - Continuous Regeneration Process

Chlorination may, on occasion, be used in conjunction with permanganate to achieve some economy in chemicals and to maintain a chlorine residual in the effluent where required by local authorities.

For an exact potassium permanganate demand, add standard strength permanganate solution to a definite volume of water until a slight pink color persists, and read the dosage direct. At 32°F, 0.23 lb. of K Mn O_4 is soluble in one gallon of water; at 68°F, 0.54 lb. of K Mn O_4; and at 104°F, 1.05 lbs.

The raw well water should, as a general rule, contain for optimum results about 4 ppm of alkalinity for each ppm of iron and manganese present. If the raw water does not contain the amount of alkalinity, additional alkalinity may have to be added artificially though this is not a hard and fast rule.

If the pH of the raw water be at or below approximately 6.3, pre-treatment of the raw water with soda ash or some other form of alkali may be required to insure complete stability of this zeolite and proper functioning of the Ferrosand Cr filtration process.

The recommended backwash rate is 8-9 gallons per sq. ft. per minute at 60°F. and the water used should be filtered water. The time required for backwashing is approximately 10 minutes.

Since the importance of maintaining the Ferrosand CR bed in a clean condition is mandatory, the Ferrosand CR Filter is equipped with an air wash system through which air is discharged from a small compressor or from the plant air supply system during periodic backwash shutdown periods.

Table 8 Ferrosand CR Filter Rates, Bed Depths, and Pressure Losses
(approximate figures)

Raw water iron and manganese in ppm	Max. filter rate in gpm/sq. ft./min.	Min. CR* depth (inches)	Head loss in psi after 10 hours operation
up to 2	5	30	15
2 - 5	4	30	15
5 - 8	3	36	15
8 - 15	2	42	15

With Ferrosand CR it is possible to operate a properly designed filter unit at a flow rate as high as 3-5 gallons per square foot of filter bed area per minute. Previously, with the manganese zeolite process and intermittent regeneration, filtration rates ranged from 1 to 3 gallons per square foot per minute which meant the use of large filtering units for accommodating relatively low filter flows.

The five principal components of the Ferrosand CR filter are the underdrain system, air wash system, gravel retaining screen, Ferrosand CR mineral, and permanganate feeder.

This underdrain system has two all-important functions: (1) to uniformly distribute the backwash water during the cleaning of the filter and (2) to uniformly collect the filtered water during the filtration process.

Washing with water alone will keep a filter moderately clean. But with water and air, the filter bed is kept very clean. The air literally "blasts" deposits away from the zeolite grain surfaces so that the wash water can then carry them out of the filter to the waste during the normal washing operation. The air wash system is designed to uniformly distribute the correct amount of air up through the entire bed depth from the very bottom to the very top.

Iron and manganese bearing waters have a tendency to tightly pack any filter bed into a cohesive mass after it has been in operation for a long number of hours. When the flow is reversed (backwashing), this filter "plug'rises in the tank and breaks very suddenly with the danger of

upsetting the various gravel supporting layers in the immediate bottom of the filter and causing serious operating difficulties. The supporting bed must, therefore, be kept level and undisturbed at all times. For this reason, a stainless steel gravel retaining screen is installed on top of the fine gravel and permanently attached to the steel shell with angle iron supports designed for the purpose.

The zeolite is refined by being processed with six different refining chemicals to have a harder and more durable grain structure so that it can be backwashed and cleaned harder, rubbed and scrubbed better, and have a longer effective life with a minimum attrition loss and material replacement. With some waters even better results are achieved by using a dual filter bed usually consisting of a lower bed of about 24" of Ferrosand CR and an upper bed of about 12" of special selected and graded Ferrofilt (anthracite coal).

H & T permanganate chemical feed machines used for a Ferrosand CR Filter are designed and built of suitable materials of construction to provide long life and operating accuracy. Feeders are both automatic and proportional in operation so that every gallon of water filtered is accurately dosed with the correct amount of permanganate, thus, insuring correct pretreatment and no wastage of the chemical.

For certain requirements under certain conditions, Ferrosand CR Filters are made: (1) of the open tank gravity flow type either new or conversions of existing filters; (2) with preaeration equipment; (3) with a filter bed comprising a mixture of CR and Ferrofilt (anthracite); (4) as conversions from existing sand or anthracite filters; (5) as conversions from existing intermittently regenerated manganese zeolite filters; (6) as polishing filters for further clarification of existing treated water supplies.

Ferrosand CR can be continuously regenerated ordinarily with 1 to 4 parts per million of potassium permanganate which is equivalent to between 8 and 32 pounds per million gallons of water, which at present prices (1965) of permanganate is equivalent to a chemical cost of between $2.40 and $9.60 per million gallons of water.

Hydrogen Zeolites. Hydrogen zeolites are made by the acid treatment of sodium or calcium zeolite (Na_2Z or CaZ) whereby the hydrogen cations of the acid (rather than sodium or calcium) is available for exchange with the undesirable cations in the water:

$$\begin{matrix} Na_2Z \\ \text{or} \\ Ca\ Z \end{matrix} + 2H^{+} + SO_4^{--} \rightarrow H_2Z + Ca^{++} + SO_4^{--}$$

The permanent hardness of water due to sulphates and chlorides will react with the hydrogen zeolites in the same manner, but in this case the resulting sulphuric and hydrochloric acids are not volatile like carbonic acid. These acids must be neutralized by adding soda ash or caustic soda or by the following procedure: A portion of the raw water is softened in a conventional sodium zeolite unit to produce soft, alkaline water. The rest of the water is softened in a hydrogen zeolite unit to produce soft, acid water. The mixture of the two effluents in the proper proportions will produce a softened water having the desired alkalinity. There are carbonaceous zeolites on the market which can be made to function either as sodium or hydrogen zeolites. Instead of the conventional sodium zeolites, part of the carbonaceous zeolite can be used to produce sodium alkalinity which will neutralize the acids produced by the other part.

Hydrogen zeolites will also replace the sodium content of water with hydrogen. Thus, soft, alkaline waters containing sodium bicarbonate can be neutralized without increasing the content of neutral salts. Furthermore, these zeolites are resistant to the action of carbon dioxide and do not contain silica. This latter feature is of significance in the removal of carbonate hardness.

The reactions with carbonaceous (hydrogen) zeolites are as follows:

$$\left.\begin{matrix} Ca\,(HCO_3)_2 \\ \text{or} \\ Mg\,(HCO_3)_2 \\ \text{or} \\ Na_2\,(HCO_3)_2 \end{matrix}\right\} + H_2Z \rightarrow \left\{\begin{matrix} CaZ \\ \text{or} \\ MgZ \\ \text{or} \\ Na_2Z \end{matrix}\right. + H_2O + CO_2$$

The carbon dioxide is expelled by aeration, leaving no alkaline compounds in contrast to treatment with sodium zeolite. Regeneration of the spent hydrogen zeolite is accomplished with diluted sulphuric acid, as follows:

$$\left.\begin{matrix} CaZ \\ \text{or} \\ MgZ \\ \text{or} \\ Na_2Z \end{matrix}\right\} + 2H^+ + SO_4^{--} \rightarrow H_2Z + \left\{\begin{matrix} Ca\,SO_4 \\ \text{or} \\ Mg\,SO_4 \\ \text{or} \\ Na_2\,SO_4 \end{matrix}\right.$$

The hydrogen zeolite (H_2Z) will exchange any dissolved cation (Ca^{++} or Na^+ or Mg^{++}) for hydrogen cation (H^+):

$$H_2Z + \left.\begin{matrix} Ca^{++} + SO_4^{--} \\ Ca^{++} + HCO_3^- \\ Mg^{++} + HCO_3^- \\ Na^{++} + Cl^- \end{matrix}\right\} \rightarrow \left\{\begin{matrix} CaZ \\ MgZ + (H^+ + \text{Anions}) \\ \qquad\qquad (\text{Acid}) \\ Na_2 \end{matrix}\right.$$

To accomplish this on a large scale, a new class of ion exchange materials has been developed, since the aluminum silicate zeolites, such as $Na_2Al_2Si_4O_{12} \cdot 6H_2O$ or $Na_2O \cdot 3SiO_2 \cdot Al_2O_3$, break up completely after several regenerations with acid. This new class, the resinous zeolites, which is not destroyed by acids has the same ion exchange properties of natural zeolites, and is more efficient.

More recently, a group of resinous ion exchange materials has been developed. These are insoluble in water, but they contain a loosely held hydroxyl anion (OH^-) which may be exchanged for the anions of an acid water. The anion exchanger is represented by the symbol ROH in which R designates a complex organic group.* When such an anion exchanger is in contact with the acid water produced in the immediately preceding equation, the anion (be it sulphate (SO_4^{--}), bicarbonate (HCO_3^-), chloride (Cl^-), or other) is removed from solution and the hydroxyl anion takes its place:

$$2\,ROH + 2H^+ + SO_4^{--} \rightarrow R_2SO_4 + 2H^+ + 2OH^-$$

The hydrogen cations and the hydroxyl anions combine to form water:

$$2H^+ + 2OH^- \rightarrow 2H_2O$$

All ions, therefore, are removed, for all practical purposes, from the water, leaving it in the pure state.

The choice between lime, or lime-soda ash, and zeolite for municipal water softening requires careful consideration of the following conditions:

* R stands for the alkyl group composed of carbon and hydrogen atoms in the proportion of $C_n H_{2n+1}$, for example, methyl = CH_3, and octyl = C_8H_{17}.

1. If no place be available or method provided for disposing of sludge, it would be unwise to build a lime-soda ash plant.

2. If the water to be softened be turbid, a lime-soda ash plant probably could be built much more economically than a combined filtratration and zeolite softening plant.

3. If a water supply be not safe bacterially, the bactericidal value of lime treatment renders the lime softening process suitable for correcting this condition.

4. If the water be excessively hard or if magnesium hardness be excessive, zeolite efficiency is reduced. Lime-ash softening is more economical if the hardness be due to calcium bicarbonates than to magnesium bicarbonates. But bicarbonates, generally, are more economically removed by lime-soda ash than sulphates, chlorides and nitrates. Excessively high alkalinity and high hardness water softened by zeiolite may not have an agreeable taste.

5. Turbid or polluted waters and waters containing oil or hydrogen sulphide tend to clog the pores of the zeolite filter bed.

6. Zeolite can remove non-oxidized iron (ferrous) in solution by "base exchange" process, but when oxidized to the ferric insoluble state it can be removed only by a down flow filter. Lime-soda ash is also an efficient iron remover.

7. Well water devoid of oxygen and containing carbon dioxide if softened too much may cause corrosion by dissolving iron from the mains.

8. The cost of lime to remove bicarbonate hardness, under normal conditions, is about one half the cost of salt. The cost of salt to remove non-carbonate hardness by zeolite, under normal conditions, is about 20% less than the cost of soda ash.

9. If the choice for the softening process be zeolite, then:

a. Greensand zeolite is usually preferred when the water contains appreciable quantities of iron, a low content of silica, or is too high or too low in pH value.

b. Synthetic gel type zeolite is usually preferred for water low in iron, or water that has been sand filtered preparatory to softening. Smaller units are required and less wash water is needed.

The Spiractor

The Spiractor is a recent development in lime-soda ash water softening equipment. It consists of an inverted conical tank in which the softening reactions take place in the presence of a suspended bed of granular calcium carbonate.

The advantages claimed for this type of softener are:

1. Equipment is small, 5 to 10 minutes detention period only is required.

2. The precipitant and removed hardness are discharged in a granular form instead of the usual wet, pasty sludge. The granular material is easy to handle as it drains to less than 5 per cent moisture in a relatively short time.

The process involves the principle of catalytic precipitation, the granules serving as nuclei around which the precipitated compounds of calcium and magnesium build up.

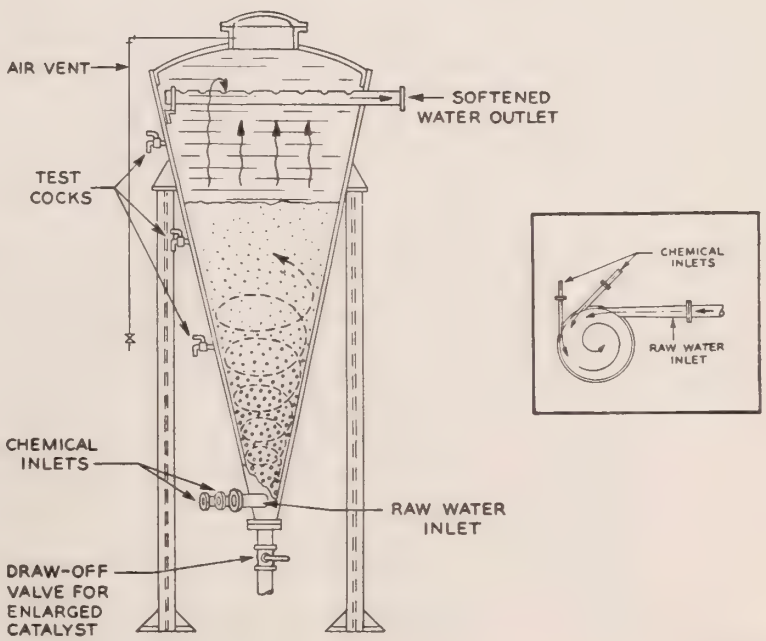


Fig. 16 Cross-Sectional View of Permutit Spiractor Showing Flow. Inset Gives Detail of Arrangement of Raw Water and Chemical Inlets

In operation, the conical-shaped tank (Fig. 16) is slightly more than half filled with fine granules of calcium carbonate (0.1 to 0.2 mm. in size). Raw water enters the bottom through a special fitting containing a tangentially disposed nozzle. Through another opening in this fitting the dosage of lime or lime-soda ash suspension is introduced. The chemicals mix with the upward swirling water. In the presence of the calcium carbonate granules, the softening reaction takes place, a contact reaction similar to that which occurs in sand filters softening unstabilized lime-soda softened water. The calcium carbonate granules grow in size just as filter sand does. As the granules grow in size and the bulk of material increases, its level is kept down to that desired by withdrawals of the largest particles from the bottom. Periodic additions of new material are required and this new material may be produced by regrinding and screening a portion of the discharged material. The water discharged from the Spiractor usually is stabilized and filtered through a sand filter.

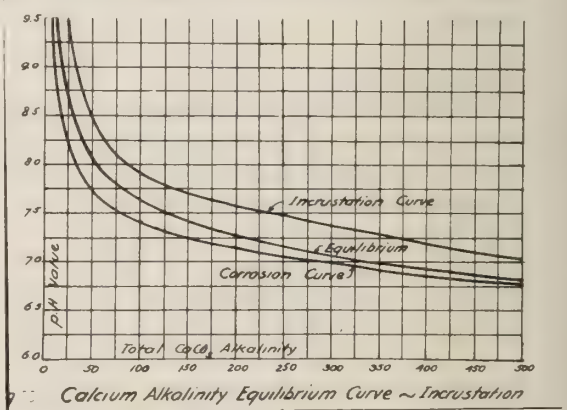
K. Corrosion and its prevention.

1) Chemical

a) Oxygen. Where the interior surface of pipes has no protective coating, the presence of oxygen in the water causes corrosion. The surface of the metal pipes is covered by a layer of hydrogen ions from the ionization of water. If an excess of oxygen be present in the water, the hydrogen ions combine with the oxygen and the excess oxygen combines with the metal and oxidizes it.

b) Carbon dioxide. Measured by pH, many so-called alkaline waters are really acid. This is likely to be the case with soft waters, the alkalinity of which is low and due to bicarbonates of calcium and magnesium. In order to maintain solution equilibrium and hold bicarbonates in solution, an excess of carbon dioxide is necessary. Carbon dioxide forms relatively weak acid when dissolved in water, and an excess of this in a low alkalinity water may be enough to increase the hydrogen-ion concentration beyond the point of true neutrality and produce an acid reaction.

Fig. 17 Calcium Alkalinity Equilibrium Curve - Incrustation and Corrosion Curves



A pH below 8.2 usually aids corrosion, since this indicates the presence of bicarbonates which may ionize and release carbon dioxide which forms carbonic acid. This process depends on the total alkalinity of the water. A water having a low alkalinity needs a high pH in order that it be non-corrosive, and conversely, a water having a high alkalinity will be non-corrosive at a lower pH than a water having a low alkalinity, as follows plainly from the corrosion incrustation curves. (Fig. 17.) Alkalinity, as used here, refers to the total ionized and un-ionized potentially alkaline minerals that may be present in the water. These usually consist of bicarbonates and sulphates of calcium, magnesium, and sodium. Carbonates and silicates of calcium and sodium in the water protect against corrosion by causing a thin film of carbonate or silicate salts to protect the inner surface of the pipes, if the pH of the water be kept within the above mentioned limits. The presence of CO_2 in the water will result in a water that will tend to be corrosive. This is thought to be due to the dissolving of the iron as the ferrous bicarbonate which is subsequently oxidized by the oxygen present to form ferric hydroxide, the familiar red-brown, rust-like precipitate. Where acidity is present, addition of more lime is necessary.

2. Electrolytic. Electric car lines produce a current of electricity in the ground which may cause corrosion.

3. Galvanic. Pipe lines composed of dissimilar materials may cause corrosion due to the electric current produced by the difference in electric potential between the two materials.

Prevention of Corrosion-Resumé.

a) To prevent corrosion, the acidity of water must be kept low and the pH not less than 8.2.

b) Water must be kept in chemical balance to calcium carbonate. Water that is supersaturated with calcium carbonate will quickly deposit a coating on the inside of the pipe,

and thus prevent the water from dissolving the iron. Water that is undersaturated with $CaCO_3$ will dissolve the $CaCO_3$ film already formed on the pipe. Care must be taken that a chemical balance be maintained so that the film does not become too thick (thus clogging the pipe), and so that the film be not dissolved away (thus allowing corrosion).

Calcium carbonate can be built up to saturation (25 or 30 parts per million) by adding lime to the water. The pH can be built up by adding soda ash (sodium carbonate) to give a slight pinkish color to water containing phenolphthalein.

c) Pipe surfaces can be lined with bitrimastic enamel and coal tar products.

d) Copper pipes are better than galvanized iron or other iron pipes. Pipe lines composed of pipes of dissimilar metal should be avoided.

e) Water should not be allowed to become too soft.

f) Stray currents which cause electrolytic corrosion should be prevented from entering water mains.

Recarbonation of Lime Softened Water*

Lime softened water which has not been recarbonated is not stable because it is supersaturated with normal carbonates of calcium and magnesium. Distribution systems carrying the water become incrusted with deposits of the carbonates. Difficulty with the deposits is encountered also in meters and hot water systems, especially in hot water pipes in hotels and public buildings, because the water in these buildings usually is heated to a temperature higher than the average.

Lime softened water has an injurious effect on sand filters. The normal carbonates deposit upon the surface of the sand grains as a crystalline coating and cause an enlargement of the particles. The sand grains become cemented together, forming hard lumps in the filters and eventually destroying the effectiveness of the filter medium. As the sand grains increase in size, the filter bed increases in depth, making it necessary to periodically remove some of the sand in order to maintain the proper freeboard between the top of the sand and the wash water troughs. Also it may be necessary to occasionally spade up the bed and crush the hard lumps. After four to ten years the filters may require rebuilding.

Lime softened water may be rendered non-incrusting by recarbonating it with carbon dioxide gas produced by burning coke, pulverized anthracite coal, oil, or gas in a suitable furnace. After passing through a scrubber and drier, the gas is diffused into the water through small openings in a grid system. It is usually applied after the water has passed through the settling basins and before reaching the filters. It is preferable, however, to provide some reaction time for the recarbonated water before it reaches the filters. The carbon dioxide neutralizes any excess lime or caustic alkalinity in the water and, if added in sufficient quantity, converts the normal carbonates to bicarbonates.

In the time since recarbonation has come into general practical use, the conception of its function has changed almost completely. The idea during the development of the process was to add enough carbon dioxide to the softened settled water to neutralize any excess lime or caustic alkalinity in the water, and to convert all of the normal carbonates to bicarbonates; in other words, to recarbonate to a pH value of about 8.3. When this was tried on a plant scale, however, it was found that the low alkalinity softened water had an aggressive reaction on deposited scale, on the precipitates already accumulated in the basins, and on the incrusted filter sand. In fact, the water after recarbonation would dissolve scale and precipitates to such an extent that the alkalinity in many cases would be more than doubled. In the light of present knowledge of calcium carbonate saturation, the increase in alkalinity can be explained readily, and computed with accuracy by means of the nomograph of the Langelier** formula, whereby the pH saturation of the water can be computed from the results of a water analysis. For example, to be in chemical balance, a sample of softened recarbonated water having an alkalinity of 35 parts per million, total solids of 300 parts per million, and calcium of 20 parts per million should have a pH of 8.9. To put this water in chemical balance at a pH of 8.3 the alkalinity

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* Water Supply and Treatment, National Lime Ass., 1957

** Journal of the American water works Association, Vol. 28, October 1936

would have to be about 130, or almost four times the alkalinity required for a pH of 8.9.

Another difficulty in recarbonating lime softened settled water to bicarbonates is the tendency to return the finely suspended calcium carbonate and magnesium hydroxide into solution. If, for example, a sample of softened, settled water were divided into two portions, and one portion recarbonated to all bicarbonates, the alkalinity after filtering both will be higher in the recarbonated sample. It is entirely probable that the increase in alkalinity is due more to the dissolving of the magnesium hydroxide than the calcium carbonate, because magnesium hydroxide can be dissolved very readily by carbon dioxide, whereas calcium carbonate is much more difficult to put into solution.

In view of the fact that lime softened water with an analysis of alkalinity, 40 or under, hardness, 85 or under, and calcium, 18 or under, must have a pH value of about 8.9 to be in equilibrium, and keeping in mind that low alkalinity oxygen-bearing water should have a plus index of from 0.4 to 0.8 to prevent red water troubles, it is apparent that recarbonation of low alkalinity water should be carried to a pH value of from 9.3 to 9.7. This will, however, leave a water that will incrust the sand filters, but it is believed to be a better policy to keep the trouble in the plant, rather than to put out a water that would be aggressive to the consumers' plumbing. If water with such a highly positive index lays down too much scale in the cold water pipes, this can be reduced by adding a trace of sodium hexametaphosphate (0.25 to 1.0 parts per million).

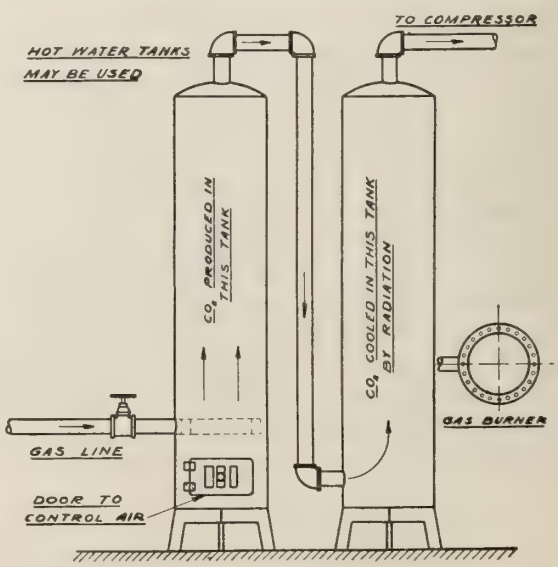
Recarbonation Not Always Necessary

Experience with both well supplies and moderately hard surface supplies have shown that rather than operate the recarbonation equipment, the sand filters are permitted to become coated with calcium carbonate which in turn produces an effluent that is reasonably stable. Even at pH values of 10.5 or so, deposition in the systems appear to be slight and after several years has occasioned no unusual complaints. The additional costs of filter maintenance have been found more justifiable than the maintenance of recarbonation equipment. In none of these cases is there any additional stabilizing treatment with polyphosphate.

Comparison of Fuels for Carbon Dioxide Production

A carbon dioxide plant should deliver gas containing as high a percentage of carbon dioxide as controllable combustion will permit, because the higher the percentage of carbon dioxide the smaller will be the air compressor or blower needed to force the gas into the water. The available fuels from which carbon dioxide can be obtained are coke, which yields about 3 pounds of carbon dioxide from 1 pound of fuel; artificial gas, which yields about 82 pounds of carbon dioxide from 1,000 cubic feet burned; natural gas, yielding about 115 pounds per 1,000 cubic feet burned; kerosene or similar oil, which yields about 20 pounds of carbon dioxide per gallon burned; and producer gas made from coke, yielding about 3 pounds of carbon dioxide for each pound of coke gasified. Apparatus for the recarbonation of water must be largely automatic and continuous, requiring a minimum of attention.

Fig. 18. Gas Burner Carbonation Plant


TO COMPRESSOR
HOT WATER TANKS MAY BE USED
CO2 PRODUCED IN THIS TANK
CO2 COOLED IN THIS TANK BY RADIATION
GAS BURNER
GAS LINE
DOOR TO CONTROL AIR

Types of Carbonation Plants

Seven types of plants have been built: (1) gas burning; (2) combined gas and coke burning; (3) oil burning; (4) combined oil and coke burning; (5) coke burning; (6) utilization of stack gas; and (7) generation and use of producer gas.

Perhaps the simplest type of plant yet built consists of a tall tank provided with a gas burner, another similar tank for cooling

the gases, a compressor or blower, and a diffuser. A plant of this kind using hot water heating tanks is shown in Fig. 18. Carbonation equipment of this type has been used when the quantity of water to be treated is less than 10,000 gallons per hour.

The type of plant commonly used when the amount of water treated is about 40,000 gallons per hour is the "Carbonation Plant Coke-Burning Stove". It consists of a coke-burning stove, a scrubber and drier, a moisture trap, a compressor, and a diffuser.

At larger water softening plants a gas producer type plant may be used to advantage. This type of plant has six principal parts; a gas producer, a gas burner, a return tubular boiler, a steam-driven air compressor, a combination scrubber and drier, and a diffuser.

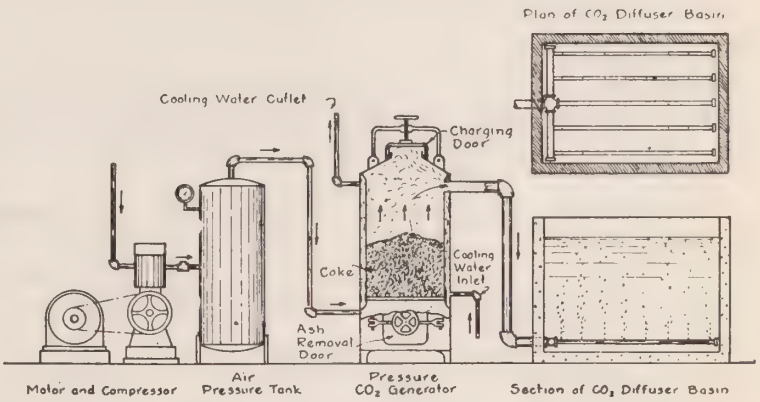


Fig. 19. Carbonation Layout Pressure CO_2 Generator Type

New Developments in Carbonation Equipment

Considerable difficulty has been and is being experienced in the operation of present day carbonation equipment because the products of combustion are corrosive and cause such damage to scrubbers, piping, and especially to cylinders and valves in the compression equipment. Two new processes have been developed which overcome the corrosive difficulties caused by the wet or moist gases:

1. The Scott Underwater Burner—A mixture of gas and air, in proper proportion, is forced to the burners by air compressors. The gas is ignited and burns beneath the surface of the water.
2. The Pressure Type of Carbon Dioxide Generator—The proportion of fuel to air is carefully regulated so that complete combustion takes place. The gas is forced to the diffusers by the pressure in the combustion chamber.

The installation of a pump which forces a spray of water against the gas, as it escapes from the diffuser openings, breaks up the bubbles making the carbon dioxide much more readily absorbed. Tests have shown that, if properly regulated an absorption efficiency of 90 per cent or over is accomplished with a submergence of only 8 feet.

Fig. 19 shows a pressure carbon dioxide generator, including spray.

Calculation of Carbon Dioxide Requirements

Carbon Dioxide may be used to convert caustic alkalinity $Ca(OH)_2$ to calcium carbonate ($CaCO_3$), to convert the calcium carbonate to calcium bicarbonate $Ca(HCO_3)_2$, or for both purposes. In computing the CO_2 needed to convert carbonates to bicarbonates, it must be remembered that any caustic alkalinity present will take one molecule of CO_2 to form $CaCO_3$, then another molecule of CO_2 to form the bicarbonate radical.

The chemical reactions are:

1. (a) $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O.$

   (b) $Ca(OH)_2 + 2CO_2 \rightarrow Ca(HCO_3)_2.$

2. $CaCO_3 + CO_2 + H_2O \longrightarrow Ca(HCO_3)_2.$

Since it is customary for all forms of alkalinity to be expressed in terms of $CaCO_3$, calculations all use 100, (the molecular weight of $CaCO_3$), rather than that of $Ca(OH)_2$ or $Ca(HCO_3)_2$. The calculations involved then are:

1. (a) Caustic alkalinity to carbonate:

$Ca(OH)_2 : CO_2 :: 100 : 44$

$$\text{p.p.m. } CO_2 = \frac{44}{100} \times \text{Ca(OH)}_2 \text{ p.p.m. (as } CaCO_3)$$

$$\text{or } CO_2\text{, lbs. per MG}^* = \frac{44}{100} \times 8.33 \times \text{Ca(OH)}_2 \text{ p.p.m. (as } CaCO_3)$$

CO_2, lbs. per MG $= 3.7 \times Ca(OH)_2$ p.p.m.

2. Caustic alkalinity to bicarbonates:

$Ca(OH)_2 : CO_2 :: 100 : 88$

$$CO_2 = \frac{88}{100} \times \text{Ca(OH)}_2 \text{ p.p.m. as } CaCO_3$$

or CO_2, lbs. per MG $= 7.4 \times Ca(OH)_2$ p.p.m. as $CaCO_3$

3. Carbonates to bicarbonates:

$CaCO_3 : CO_2 :: 100 : 44$

$$CO_2 = \frac{44}{100} \times CaCO_3 \text{ p.p.m.}$$

CO_2, lbs. per MG $= 3.7 \times CaCO_3$ p.p.m.

Dry Ice or Liquid Carbon Dioxide Carbonation

The use of dry ice or liquid CO_2 in recarbonation eliminates the need of combustion and pressure equipment. Liquid carbon dioxide can be purchased in cylinders. Dry ice can be stored in gas-tight steel cylinders in capacity ranging up to one thousand pounds per cylinder. As the carbon dioxide changes from the solid or liquid to the gaseous state, pressure is developed which carries it from the generating cylinder through a heated coil submerged in warm water and also through pressure-regulating valves directly to the diffusers. The amount used can be easily controlled and regulated with a rotameter. Being pure CO_2 and not diluted with nitrogen or excess air which are present when the carbon dioxide is produced by burning fuel, the volume of gas to be handled is considerably reduced; the carrying and diffuser pipe capacities can be held to a minimum. The danger of producing carbon monoxide is eliminated. Simplicity of installation and control equipment required makes its use for small plants desirable. The cost at present makes producer gas more economical for larger plants.

Recarbonation with Sodium Bicarbonate

Excess caustic alkalinity may be neutralized by sodium bicarbonate in the reaction:

$Ca(OH)_2 + 2NaHCO_3 \longrightarrow CaCO_3 + Na_2CO_3 + 2H_2O$. This treatment is more expensive than the application of CO_2, however it is useful where recarbonation is needed only at certain times of the year. Where lime is utilized to remove the bacterial load of a surface supply the amount of lime required, particularly during late winter and early spring, may be somewhat greater than permissable to leave in the water. In such cases, the additional

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* MG = million gallons.

chemical cost of bicarbonate treatment may be less than the labor cost of maintaining the CO_2 producers in operating condition.

Since one molecule of soda ash is formed for every two molecules of bicarbonate used, this additional softening reaction requires (a) reduction in soda ash dosage and (b) mixing and sedimentation time following the application of this treatment.

Actual experience has shown that the quantities required approach the theoretical calculations very closely; for computation, one grain per gallon of sodium bicarbonate may be considered to convert 10 ppm. of $Ca(OH)_2$ to $CaCO_3$, and also reduce the soda ash requirements by 0.6 grains per gallon.

Special Problems.

a) Water for making ice should be:
   1) Sparkling clear and free from taste and odor.
   2) Bacteriologically pure.
   3) Free of carbonates and bicarbonates of calcium and magnesium.
   4) Free of iron.
   5) Sulphates, chlorides, and sodium carbonate which together amount to:
      Less than 171 p.p.m. should give first quality ice.
      Between 171-256 p.p.m. should give good ice.
      Between 256-342 p.p.m. should give merchantable ice.
      Between 342-684 p.p.m. should give questionable merchantable ice.
      Over 684 p.p.m. should give ice that is not merchantable.

b) Water used for carbonated beverages should have the following qualities:
   1) Clear and tasteless - free of algae.
   2) Alkalinity may reach 100 p.p.m.
   3) Iron and manganese may reach 0.2 p.p.m.
   4) Aluminum may reach 0.2 p.p.m.
   5) All chemicals must be in equilibrium to prevent settling out.

c) Water used for foods and beverages should -
   1) Meet drinking water standards.
   2) Be good tasting and sparkling clear.
   3) Be free of iron and manganese.

Fluoridation of Public Water Supplies. The existence of fluoride in drinking water was discovered in 1931, and in the same year was identified as the causative agent of mottled enamel of the teeth. Subsequent research in many states and other countries showed that this condition only exists where the concentration of fluoride is higher than 1 p.p.m. Moderate to severe cases occur starting at a concentration of 1.7 p.p.m.; and when the concentration goes to 6 p.p.m. and over, an almost universal effect occurs in the population, especially children.

Furthermore, it was found that much of the dental caries decreased with the increase of the fluoride concentration. This finding led to the assumption, first suggested in the thesis of Dr. David B. Ast, that deliberate treatment of the public water supply with a moderate dosage of fluoride could be used as mass prophylaxis for the reduction of dental caries in children. In a report on this thesis, the New York State Department of Health in 1943 suggested a plan for an experimental demonstration, treating the water of the city of Newburgh, N.Y. with 0.8 p.p.m. of fluorine and using the nearby city of Kingston, N.Y. as a control. Both cities were as much alike in population, age groups, and similar factors as could be desired. This plan, to last at least 10 years, was enacted in the spring of 1945. By the end of 1952, the school children in Kingston showed no change in tooth decay incidence, but in Newburgh there was 47% less tooth decay among the 6 to 12 years age group. In the 6 and 7 year old children, who have been drinking fluoridated water from birth, the decrease in caries was 60%.

The first application of sodium fluoride to a municipal water supply was made in Grand Rapids, Michigan, on January 24, 1945. Since then, there has been a rapid development of fluoridation.

Fluoridation Chemicals

Fluoride is added to the water supply in the dry or solution state. The form of fluoride mostly used in the United States at the present time is Sodium Silicofluoride (mainly in dry state), Sodium fluoride (mainly in solution), and Hydrofluosilicic Acid solution. Other forms of fluoride used are Ammonia Fluosilicate (solution mainly) and calcium fluoride solution.

In the table below are listed the three forms in which the fluoride usually is procured. Several other compounds have been used, but only to a very limited extent:

Properties of Fluoride Used in Water Treatment

	Sodium Fluoride	Sodium Silicofluoride	Hydrofluosilicic Acid
Formula	NaF	Na_2SiF_6	H_2SiF_6
Purity Range	95-98*	98*-99	30%
% Fluoride, approx.	44*	60*	24
Usual Form Available	Crystalline	Powdered	Liquid
Solubility, lbs. per gal. at 60^{o} F.	0.35 lbs/gal	0.054 lbs/gal	In solution

The selection of type of material to use will depend not only on the cost per pound, but must take into consideration the availability of the compound, the quantities required, the storage facilities available or required, the feeding devices needed, and the point of application.

Application

The optimum point of application of fluorides is to the filtered effluent. There will be a considerable loss in the coagulation and softening processes, if such be used, making it necessary to use larger dosages of fluoride if it be introduced with the other chemicals. Gravity feed of the fluoride solution, particularly if dry feeders and dissolving tank be used, will generally be less troublesome, and may be a factor in selecting a place to apply this treatment.

Because of the limited solubility of the dry materials, the feeding devices must include a dissolving tank of adequate capacity to dissolve completely all the fluorides being fed. The liquid fluosilicic acid does not present this problem, in fact it is preferable to feed this in the concentrated form in which it is purchased, so as to avoid the possibility of forming a silica gel in the diluted solution.

Also, if eductors be necessary to discharge any of the solution under pressure, softened water should be used to avoid the formation of calcium and magnesium fluorides at the points of greatest agitation. Softening agents such as one of the polyphosphates can be fed to the water supplying the eductors, and thus minimize the scale forming tendencies.

Feeders

Liquid hydrofluosilicic acid, which many small plants find most convenient, may be fed by a diaphragm type proportioning pump such as is used to feed hypochlorite solutions. This is often pumped directly from the original drum which may be placed on a platform scale to check on quantity fed. Where large quantities of the liquid are to be handled, bulk storage and a dipper type liquid feeder may be desirable.

The dry forms of fluoride (sodium fluoride and sodium silicofluoride) usually are used in

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* Purity used in computing cost per MG (million gallons).

the larger plants, and may be fed by one of several commercially available dry feeders, or possibly by a saturator, in which batches of known strength are prepared and then applied by a pump, an eductor, or by gravity.

Hazards

Since all fluorides are poisonous in all but minute amounts, careful attention must be given to the various hazards that are involved. First of all, the operator should follow all instructions furnished by the manufacturer, and be sure to wear protective clothing, gloves, masks, goggles, when handling the material. Breathing or swallowing any of the substance must be avoided.

Secondly, the selection, installation, and operation of the feeding devices must be directed towards eliminating any and all possibilities of overfeeding the fluoride. Any appreciable overdose will mean a dangerous and possibly very serious condition in the treated water. The feeding devices must be of proper design, so as to be extremely accurate, uniform in feeding and dissolving action, and fool-proof as to flooding or over-feeding. Also the operator must maintain careful dosage checks and keep accurate reports of quantities fed.

Third, the solution containing either sodium silicofluoride, or hydrofluosilicic acid are corrosive, and the installation and operation must be made to not only minimize leakage and spillage, but to eliminate hazards to personnel if such should occur.

Bulk Storage of Dry Fluorides

The more granular sodium silicofluoride can be purchased in bulk in truckload or carload lots at considerable saving in cost over the packages, and can be handled reasonably well. However, the sodium silicofluoride, generally preferred because of its lower cost per pound and higher fluoride content, is more difficult to store and convey from bin to feeder. This material has greater tendency to pack and to become caked by absorbed moisture, also it is corrosive and should not be stored in metal bins. Experience has shown that storage in original package, preferably the 400 lb. drums, may eliminate handling difficulties.

Fluoride Removal

The presence of fluorides in water in quantities above one part per million is looked upon with suspicion, and when more than 2 parts per million are present it is considered dangerous because if water with this quantity of fluorides present be used for drinking and cooking during the period of teeth calcification it causes "mottled enamel".

Removal of Fluorides. Scott, Kimberly, Ey, and Waring noted that the fluoride concentration in the effluents from lime softening plants shows a substantial reduction as compared to the fluoride in the raw water. No reduction, however, was noted in zeolite-softened water. They established that there was a definite relation between magnesium and fluoride reduction. Fluoride reduction is equal to approximately 7 per cent of the initial fluoride multiplied by the square root of the magnesium removed. Other methods of fluoride removal have been proposed but there is not much evidence available to show how effective or practical they are on a plant scale.

Some of the compounds suggested are: aluminum sulphate, activated aluminum, defluorite, tricalcium phosphate, calcium phosphate, and ground bone.

Household Fluoride Removal Units. Household fluoride removal units are available. They are similar in size to a household hot water tank and are filled with granular tricalcium phosphate. When they become exhausted,they are regenerated with a 1 per cent caustic solution followed by 0.7 per cent hydrochloric acid, and a final rinse with clear water. The capacity of the regenerated phosphate is substantially less than the original capacity.

Laws and Regulations

Since fluoridation has been gaining popularity, several states have issued regulations for its control. The general trend in the past has been to leave the judgment as to its merits, the decision for its installation, and its operation to local authorities, and the supervision to the State.

However, recently, a movement was sponsored by the American Dental Association for encouraging State legislative action for mandatory application of fluoride to public water supplies. Success has been attained in establishing state laws for fluoridation in Connecticut and Kentucky, and by mid-1967, three more states passed such laws. These states are Minnesota, Illinois, and Michigan. The Connecticut law requires the fluoridation of public water supplies in order "to maintain a fluoride content of between eight-tenths of a milligram per liter and one and two-tenths milligrams per liter".

Table 8. Chemical and Feeder Used in Fluoridating Water Supply Systems By Range of Population Served as of December 31, 1966

Population Size of Water Supply Systems	Number of Systems Fluoridating	Sodium Fluoride		Sodium Silicofluoride		Fluosilicic Acid Solution	Ammonium Fluosilicate		Calcium Fluoride Solution	Other, Adjusted Natural Fluoride, And Not Specified
		Dry	Solution	Dry	Solution		Dry	Solution		
Totals	1,785	147	412	710	67	383	1	6	1	58
1,000,000 and OVER	5			1		4				
500,000 thru 999,999	13			11		2				
250,000 thru 499,999	16	4		9	1	1		1		
100,000 thru 249,999	47	6	1	26	2	12				
50,000 thru 99,999	60	2	1	47	2	8				
24,000 thru 49,999	140	19	8	80	10	19	1	1		2
10,000 thru 24,999	335	37	33	192	8	56				9
5,000 thru 9,999	344	41	57	167	12	61		1		4
2,500 thru 4,999	303	21	86	115	10	66		2		3
1,000 thru 2,499	342	17	137	58	17	105		1		7
UNDER 1,000	144		89	2	5	48				
NOT SPECIFIED	36			2		1				33

The following administrative procedure is being followed in a number of states in relation to minimum requirements for fluoridation equipment:

1. Local officials should submit to local and state health authorities:
   a. An application for approval of plans and specifications and for fluoridation program.
   b. A copy of the local official authorization for fluoridating the supply and any ordinances or regulations pertaining thereto.
   c. A duplicate set of plans for chemical feed equipment and associated facilities proposed to be installed, and descriptive literature from the manufacturer of the equipment.
   d. A set of specifications.
   e. Engineering report which may have been prepared.
2. The operator to be responsible for maintenance and operation of fluoridation equipment must meet qualifications of State Department of Health.
3. Provisions for training the responsible operator must be made.

Recommended Water-Sanitation Practice United States Public Health Service.

Physical Features of Water-Supply Systems and their Sanitary Protection. According to the Public Health Service Drinking Water standards definition, a "water supply system includes the works and auxiliaries for collection, treatment, and distribution of the water from the source of supply to the free-flowing outlet of the ultimate consumer." Sanitary protection is concerned with all those parts of a water system which come within this definition, though for practical purposes, attention may be concentrated mainly on those parts which have to do with the sources, treatment and distribution of the water.

In order that persons concerned with the sanitation of water supplies may have the necessary information upon which to base an opinion concerning a water supply and to make recommendations, it is required that each water supply coming under consideration should be carefully studied

Table 9. Fluoridation In the United States, 1945 - 1966
Institution, Discontinuance, and Reinstitution of Controlled Fluoridation

Year**	Fluoridation Status at End of Each Year			Fluoridation Instituted Whether or Not Discontinued			Fluoridation Discontinued Whether or Not Reinstituted			Fluoridation Reinstituted After Discontinuance		
	Number of Communities	Number of Water Supply Systems	Population*	Number of Communities	Number of Water Supply Systems	Population*	Number of Communities	Number of Water Supply Systems	Population*	Number of Communities	Number of Water Supply Systems	Population*
1945	6	3	231,920	6	3	231,920						
1946	12	8	332,467	12	8	332,467						
1947	16	11	458,748	16	11	458,748						
1948	26	13	581,683	26	13	581,683						
1949	49	29	1,062,779	49	29	1,062,779						
1950	100	62	1,578,578	101	63	1,595,128	1	1	16,550			
1951	368	171	5,079,321	370	173	5,108,771	2	2	29,450			
1952	751	353	13,875,005	758	360	14,079,130	7	7	204,125			
1953	1,007	482	17,666,339	1,019	494	17,751,207	14	14	256,399	2	2	171,531
1954	1,194	572	22,336,884	1,226	602	23,528,254	36	34	1,367,021	4	4	175,651
1955	1,347	672	26,278,820	1,407	719	27,883,734	66	53	1,795,464	6	6	190,550
1956	1,583	772	33,905,474	1,656	828	35,672,794	83	66	1,999,575	10	10	232,255
1957	1,717	879	36,215,208	1,801	938	38,124,663	97	72	2,215,118	13	13	305,663
1958	1,890	995	38,461,589	1,986	1,060	40,463,466	111	80	2,311,813	15	15	309,936
1959	1,990	1,081	39,628,377	2,093	1,153	41,801,740	120	89	2,509,084	17	17	333,721
1960	2,111	1,172	41,179,694	2,221	1,251	43,390,924	127	96	2,546,951	17	17	333,721
1961	2,197	1,249	42,201,115	2,301	1,328	44,418,750	130	99	2,563,530	26	20	345,895
1962	2,321	1,350	44,045,392	2,429	1,433	46,289,156	134	103	2,589,659	26	20	345,895
1963	2,612	1,482	46,678,380	2,723	1,567	49,002,866	143	111	2,760,035	32	26	470,548
1964	2,758	1,573	48,363,066	2,869	1,659	51,179,019	152	120	3,466,178	41	34	651,225
1965	3,030	1,682	59,855,024	3,141	1,786	63,873,219	163	127	4,905,568	52	38	887,373
1966	3,145	1,785	62,427,290	3,257	1,872	66,446,000	165	129	4,961,594	53	42	942,884

* Includes Adjustment for Population Growth Based on the Bureau of the Census Population Estimates

** Year reported to USPHS

Table 10. Controlled and Natural Fluoridation, United States, 1966

States	PERCENTAGE OF POPULATION On Public Water Supplies		
	Using Controlled Fluoridation	Using Natural Fluoridation	Using Nat. and Controlled Fl.
Total	40.6	6.4	47.0
Alabama	33.9	1.1	35.0
Alaska	76.2	---	76.2
Arizona	1.1	7.5	8.6
Arkansas	52.4	1.2	53.6
California	10.6	2.6	13.2
Colorado	50.1	34.2	84.3
Connecticut	29.4	0.1	29.5
Delaware	54.1	---	54.1
D.C.	100.0	---	100.0
Florida	20.2	7.8	28.0
Georgia	36.9	2.4	39.3
Hawaii	13.1	---	13.1
Idaho	21.2	27.8	49.0
Illinois	68.1	7.9	76.0
Indiana	65.8	8.2	84.7
Iowa	59.4	25.3	84.7
Kansas	37.8	10.3	48.1
Kentucky	65.0	0.7	65.7
Louisiana	3.8	3.4	7.2
Maine	25.2	0.1	25.3
Maryland	93.4	1.1	94.5
Massachusetts	7.8	---	7.8
Michigan	30.0	2.4	32.4
Minnesota	78.1	1.6	79.7
Mississippi	20.3	6.1	26.4
Missouri	54.6	3.3	57.9
Montana	7.9	29.3	37.2
Nebraska	5.5	6.2	11.7
Nevada	0.9	4.0	4.9
New Hampshire	10.1	0.9	11.0
New Jersey	12.7	1.2	13.9
New Mexico	13.1	66.1	79.2
New York	72.9	0.1	73.0
North Carolina	57.5	1.6	59.1
North Dakota	66.0	9.7	75.7
Ohio	36.9	3.3	40.2
Oklahoma	48.0	18.7	66.7
Oregon	16.3	1.4	17.7
Pennsylvania	43.4	---	43.4
Rhode Island	89.3	0.2	89.5
South Carolina	26.2	4.4	30.6
South Dakota	21.5	21.4	42.9
Tennessee	54.6	---	54.6
Texas	15.4	45.2	60.6
Utah	0.7	2.5	3.2
Vermont	23.6	---	23.6
Virginia	83.2	2.2	85.4
Washington	10.6	6.6	17.2
West Virginia	75.9	0.1	76.0
Wisconsin	87.6	3.4	91.0
Wyoming	9.5	24.0	33.5
Puerto Rico	88.7	---	88.7

Table 11. Population in United States and Puerto Rico Using Controlled and Natural Fluoridation as of December 31, 1966

States	Total 1/ Population (Dec. 31, 1966)	Pop. on Public Water Supplies Using Nat. and Controlled Fl.	% Pop. Using Natural and Controlled Fl.
Total	199,573,000	72,329,900	36.2
Alabama	3,535,000	783,100	22.2
Alaska	274,000	115,800	42.3
Arizona	1,639,000	124,100	7.6
Arkansas	1,960,000	569,500	29.1
California	19,183,000	2,349,400	12.2
Colorado	1,991,000	1,382,900	69.5
Connecticut	2,898,000	681,600	23.5
Delaware	517,000	206,800	40.0
D.C.	811,000	811,000	100.0
Florida	6,014,000	1,308,600	21.8
Georgia	4,493,000	1,227,900	27.3
Hawaii	721,000	91,500	12.7
Idaho	694,000	224,000	32.3
Illinois	10,767,000	6,929,800	64.4
Indiana	4,933,000	2,410,900	48.9
Iowa	2,741,000	1,589,300	58.0
Kansas	2,252,000	827,300	36.7
Kentucky	3,189,000	1,200,400	37.6
Louisiana	3,623,000	195,800	5.4
Maine	981,000	148,900	15.2
Maryland	3,651,000	2,694,400	73.8
Massachusetts	5,391,000	390,100	7.2
Michigan	8,398,000	1,903,200	22.7
Minnesota	3,581,000	1,723,600	48.1
Mississippi	2,335,000	310,600	13.3
Missouri	4,519,000	1,925,600	42.6
Montana	702,000	176,700	25.2
Nebraska	1,455,000	122,900	8.4
Nevada	464,000	19,700	4.2
New Hampshire	685,000	49,600	7.2
New Jersey	6,956,000	851,800	12.2
New Mexico	1,026,000	594,200	57.9
New York	18,335,000	11,747,500	64.1
North Carolina	5,030,000	1,504,800	29.9
North Dakota	649,000	260,500	40.1
Ohio	10,342,000	3,226,300	31.2
Oklahoma	2,464,000	1,244,300	50.5
Oregon	1,962,000	264,100	13.5
Pennsylvania	11,580,000	4,039,600	34.9
Rhode Island	902,000	722,500	80.1
South Carolina	2,603,000	447,100	17.2
South Dakota	679,000	171,000	25.2
Tennessee	3,897,000	1,387,200	35.6
Texas	10,825,000	5,282,800	48.8
Utah	1,015,000	30,200	3.0
Vermont	405,000	55,800	13.8
Virginia	4,550,000	2,483,300	54.6
Washington	2,986,000	420,800	14.1
West Virginia	1,782,000	836,800	47.0
Wisconsin	4,171,000	2,458,700	58.9
Wyoming	329,000	82,500	25.1
Puerto Rico	2,688,000	1,723,100	64.1

Source:

1/ Bureau of the Census: United States Census of Housing; 1960, Series HC (1), Nos. 1-52. Includes adjustments for population growth based on U.S. Census estimates; as shown in Bureau of the Census: Current Population Reports; Population Estimates (Series P-25, Number 348, September 16, 1966).

with reference to its source and protection. The precise scope of such a study and of the report thereon will vary according to the circumstances existing in each individual case and cannot be fully specified in any general terms. The general procedure should be substantially as follows:

1. A sanitary survey of the water supply should be made by a competent person. The reliability of the data collected will depend largely upon the competence of the person by whom the survey is made. Hence, the careful selection of personnel for this duty is of primary importance. The qualifications which constitute "competence" cannot be precisely defined. In general, the person making the survey should have received a technical education in the basic sanitary sciences equivalent to that given in a course in sanitary engineering in a recognized college of engineering or school of public health. He should have a broad knowledge of the sanitary features and physical facts concerning potable water supplies and their sources, and should understand the essential features of water-purification plants and systems, their operation, and proper methods of laboratory control.

2. A brief general description of the water supply should be submitted. This should include:

a. The name of the owner of the supply.
b. A brief description of sources and catchment areas.
c. A brief description of the storage available both prior to and following treatment.
d. A brief description of the plant, including the date of installation of the main works, and a record of subsequent extensions or alterations.

3. A partial summary of the pertinent facts relating to the sanitary condition of the water supply, as revealed by the field survey, should be submitted. The following outline will serve to indicate the general scope of a survey. Not all of the items are pertinent to any one supply, and in some cases items not in the list would be important additions to the survey list. Reference should be made to the subsequent parts of this manual for certain detailed recommendations bearing on various parts of this outline.

A. Ground Water Supplies

1. Character of local geology; size and topography of catchment area; slope of ground surface.

2. Nature of soil and underlying porous strata-whether clay, sand or gravel; thickness of water-bearing stratum; depth of water table; location and log of wells in vicinity in use or abandoned.

3. Slope of water table, preferably as determined from observational wells, or as indicated presumptively but not certainly, by slope of ground surface.

4. Extent of drainage area likely to contribute water to the supply; population on the drainage area.

5. Nature, distance, and direction of local sources of pollution.

6. Possibility of surface-drainage water entering the supply, and of wells becoming flooded; methods of protection.

7. Methods used for protecting the supply against pollution, by means of sewage treatment, waste disposal, and the like.

8. Well construction: Material, diameter, depth of casing; depth to strainers or perforations; length of strainers or perforations.

9. Protection of collecting well at top and on sides; protection other than check valve, or gate valve, against backflow of drain; protection of collector lines, etc.

10. Pumphouse construction (floors, drains, etc.); capacity of pumps; drawdown when pumps are in operation.

11. Availability of an impure supply, usable in place of normal supply, hence involving danger to the public health.

12. Disinfection; equipment; supervision; laboratory control.

Examples of Sanitary Defects in Ground Water Supplies.

1. Caves, sink holes, or abandoned borings, used for surface drainage or sewage disposal, in vicinity of the source; fissures or open faults in strata overlying water-bearing formation.

2. Casing of tubular wells leaky, or not extended to sufficient depth, or not extended above ground or floor of pump room, or not closed at top; or casing improperly used as a suction pipe.

3. Collecting well, or reservoir, subject to contamination by backflow of polluted water through improper drain or by entry of surface drainage. Lack of covers, improperly designed

manholes, vent opening, etc., which may permit contamination.

4. Source of supply or structures subject to flooding.

5. Use of tile pipes, or other conduits, that are not tight where the ground water may be contaminated.

6. Leak in systems under vacuum.

7. Air-lift line, or lines, cross-connected to a sewer or secondary water supply.

8. Wells located near sewers; pit privies; cesspools; septic tanks; subsurface tile systems; drains; barnyards; pits below ground surface; or other sources of contamination.

9. Wellheads, well casings, pumps, pumping machinery, exposed suction pipes, or valve boxes connected with suction pipes,. located in pits extending below the ground surface.

10. Manufacturing and industrial plant wastes discharged on watersheds, or into underground strata causing contamination of ground-water supplies.

B. Surface-Water Supplies, Unfiltered.

1. Nature of surface geology; character of soils and rocks.

2. Character of vegetation; forests; cultivated and irrigated land, including salinity, effect of irrigation water, etc.

3. Population and sewered population per square mile of catchment area.

4. Methods of sewage disposal, whether by diversion from watershed or by treatment.

5. Character and efficiency of sewage-treatment works on water-shed.

6. Proximity of sources of fecal pollution to intake of water supply.

7. Proximity, sources and character of industrial wastes, oil-field brines, acid mine waters, etc.

8. Adequacy of supply as to quantity.

9. For lake or reservoir supplies: Wind-direction and velocity data; drift of pollution, sunshine data (algae).

10. Character and quality of raw water: Coliform organisms (M. P. N.); algae; turbidity; color; objectionable mineral constituents.

11. Nominal period of detention in reservoir, or storage basin.

12. Probable minimum time required for water to flow from sources of pollution to reservoir, and through reservoir to intake.

13. Shape of reservoir, with reference to possible currents of water, induced by wind or reservoir discharge, from inlet to water-supply intake.

14. Measures taken to prevent fishing; boating; landing of airplanes; swimming; wading; ice cutting; permitting animals on marginal shore areas, and in or upon the water, etc.

15. Efficiency and constancy of policing.

16. Disinfection of water: Kind and adequacy of equipment; duplication of parts; effectiveness of treatment; adequacy of supervision and laboratory control; contact period after disinfection; whether residual free chlorine or chloramines used in chlorinated water; residuals carried.

17. Pumping facilities: Pumphouse; pump capacity and stand-by units; storage facilities.

Examples of Sanitary Defects:

1. Absence, or inadequacy, of chlorination, or lack of proper control of chlorination; insufficient contact period when chloramines only are present in treated water.

2. No restrictions on recreational use of streams and reservoirs, together with their marginal lands, in the local catchment area.

3. Existence of sources of pollution, such as population on watershed, lumbering, hunting, grazing, and other activities; leaching cesspools, or sewers draining into streams or lakes of the catchment area, or into the marginal lands adjacent to them.

4. Improper location of intake with respect to bottom of reservoir and current, or to surface-drainage-water inlets.

5. Intake exposed and accessible to trespassers.

6. For lake supplies: Vessels passing near intakes; drift of ice fields; dumping of dredgings, garbage, etc., into lake near intakes; inadequate toilet facilities on cribs.

C. Surface Water Supplies, Filtered.

1. Catchment area: Size, topography; population density, sewered and unsewered; surface geology; reservoirs, their capacity and location.

2. Sources of pollution: Nature; distance from intake, including miles and rate of flow; amounts and distances of sewered population.

3. Sewage treatment on watershed: Extent; methods; population served; effectiveness and uniformity of results.

4. Raw-water characteristics: Turbidity, color, alkalinity, hardness, iron, etc.; bacterial quality, average and ranges; variations in quality, especially after heavy rainfall or at times of high run-off.

5. Capacity of filter plant (M. G. D.): Rated output, average and maximum daily; maximum capacity of raw-water pumps; stand-by equipment.

6. Coagulant system: Type, as solution or dry feeding; chemicals used; dosage rates, average, maximum, and minimum; number and capacity of units; reserve units.

7. Mixing and flocculation basins: Type, flash mixing, average and minimum times, flocculation, average and minimum times; number, size and arrangement of units; provisions for cleaning.

8. Sedimentation basins, number, size and retention capacity; plain sedimentation; post-coagulation sedimentation; methods of cleaning; flexibility of operation; efficiency of turbidity and bacterial removal.

9. Filters: Pressure or gravity type; number; sizes and rated capacity, net filtering area; effective size and uniformity coefficient of sand; washing system, direct or from storage, rates of wash-water application; loss-of-head gages; rate controllers, average and maximum rates of filtration.

10. Filtered-water storage: Capacity; location; arrangement; covered or uncovered; protection against contamination; methods of cleaning; added storage in distribution system.

11. Aeration: Purpose; kind; capacity; location in purification system; efficiency.

12. Disinfection: Kind; stages, if more than one; location in purification system; capacity; method of operation; operation control; average, maximum and minimum dosage; chlorine—ammonia ratios, if ammonia be used; simple or "break-point" chlorination, if used; efficiency of each stage; period of chlorine or chloramine contact before delivery.

13. Plant operation and control: Technical supervision, trained or untrained, full-time or part-time; number of operators; laboratory control, kind and frequency of tests; plant and laboratory records, kind, extent, use, etc.; meteorological records.

Examples of Sanitary Defects:

1. Excessive raw-water pollution in relation to extent of treatment provided; existence of nearby uncontrolled sources of raw water pollution.

2. Bypass connections for raw water, or partially treated water, whereby such waters may be discharged into the distribution system.

3. Existence of cross-connections, bypasses, or concrete channel walls within the plant, such as between conduits or basins carrying untreated or partly treated water, and those containing completely treated water.

4. Lack of reserve capacity of treatment works, necessitating excessive overloading, or occasional bypassing of units.

5. Lack of competent supervision and operation, or of adequate laboratory control.

6. Deficient or inaccurate operation or laboratory records.

7. Lack of suitable devices for measuring and recording volumes of water treated; for maintaining continuity of coagulant and chlorine dosage; deficient retention periods in settling basins; or areas, depths, sizes of sand and washing facilities for filters.

8. Lack of or deficiency in proper chlorination equipment and control, or failure to maintain proper chlorine residuals in the treated effluent at all times.

9. Lack of suitable protection for purified water; storage capacity less than requirements for safety.

10. Improper location of water-treatment plant or inadequate protection with respect to flood waters.

D. Pumping Station and Collecting System

1. Location and protection with reference to flooding.

2. Number, type and capacity of pumps, including reserve; condition of equipment and method of operation; condition of suction pipes.

3. Location of suction pipes relative to sources of pollution.

4. Emergency intakes.
5. Emergency supply of power; record of power shut-down; effect of shut-down on surges through conduits, etc.
6. Recording apparatus on suction-well elevation; rise and fall of suction - well elevation.
7. Screens for fish and debris.
8. All sewers cast iron, or otherwise.
9. Curb walls around suction wells to protect against surface drainage.
10. Continuous or intermittent operation.

Examples of Sanitary Defects:

1. Leaky suction pipes.
2. Pump not self priming; unsafe water used for priming.
3. Suction well subject to pollution through backflow of polluted water through drain.
4. Suction well or suction pipes unprotected from surface or subsurface pollution.
5. Improper location or inadequate protection with reference to flood waters.
6. Lack of suitable provision for ensuring continuity of pumping service under all possible conditions.

E. Distribution System (Exclusive of reservoirs or stand-pipes)

1. Area and population supplied, proportion to total within corporate limits.
2. Adequacy of distribution system with respect to area served; sizes of mains and laterals, circulation of water; storage provided.
3. Type of distribution system: Whether gravity, direct pumping, indirect pumping, including capacity of pumps, etc.
4. For above water crossings; Flexibility of pipe joints for maintaining tightness under forces due to vibration and temperature changes including freezing; protection of pipe from impact of run-away vehicles, flood waters, and objects carried by flood waters.
5. For underwater crossing: Use of flexible watertight joints; provision of valves located above flood level at each end of crossing; duplicate lines; equipment installed for making pressure tests to detect leakage; sampling taps at each end of crossing; provision for blowing off such sections of pipe to waste above ground level; distance pipe is laid below bottom of stream bed.
6. Use of common or separate trenches for laying water mains and sewage; practice concerning crossings of water and sewer lines.
7. Disinfection procedure followed in laying new mains, or repairing existing mains.
8. Method of draining hydrants: Sewers, dry wells, ground surface, other.
9. Elevation of booster-station floor level with regard to ground level; location of booster-pump suction lines relative to sources of pollution; possibility of developing negative heads in booster-pump installations drawing directly from the distribution system.
10. Method of delivery of water from public supply to some other water system which uses unsafe water.
11. Adequacy of piping system for maintenance of positive pressure in all parts of the distribution system, under normal usage, at all times.

Examples of Sanitary Defects:

1. Existence of cross-connections between primary supply and secondary supply of questionable safety at any point in the distribution system.
2. Return to the system of any water used for cooling; hydraulic operations, etc. (This is not intended to rule out the use of barometric-type condenser, or an entirely closed cooling circuit, at the water-supply plant.)
3. Absence of, or inadequate, protection; lack of covers; improper location of distribution reservoirs, standpipes, or elevated pressure tanks.
4. Intermittent service, resulting in reduced or negative pressures in distribution system; sizes of mains and laterals inadequate for preventing negative pressures; presence of dead ends permitting reduced or negative pressures.
5. Connections to sprinkler systems using toxic solutions as antifreeze.
6. Repumping on consumer premises when pressure is low, causing negative head.
7. Connection to sewers and sewer-flushing chambers, and improperly located blowoffs in distribution system.
8. Existence of hydrant drain lines connected to sewer.

9. Presence of a secondary nonpotable water system on premises where a public system exists, unless adequate regulations and enforcement are provided to prevent the occurrence of cross-connections.

10. Lack of, or inadequate, enforcement of plumbing regulations and/or ordinances designed to protect the water supply against the possibility of backflow from plumbing fixtures or from mechanical equipment supplied with water from the public water supply.

11. Connection of new pipe lines to the system without prior disinfection of pipes.

12. Existence of tile, or other leaky pipes, in distribution system.

13. Improper location of water pipes in relation to sewers and storm-water drains.

F. Storage (Reservoirs on Distribution System)

1. Use, location, and capacity of reservoirs and standpipes.

2. Reservoir sites, protection from trespassers; location with respect to sources of pollution; character of local geology.

3. Hazard of entry of flood and drainage waters; elevation of top of storage units with respect to highest known water level of any lake, pond or stream, the waters of which may approach storage units; precautions taken to divert surface drainage from the storage units; water tightness of reservoir or storage unit.

4. Point of discharge, as sewers, ground surface, etc., of overflows, blow-offs, clean-outs, and drains from roof or bottom of water-storage units.

5. Elevation above ground level of walls of surface storage units.

6. Protection of valve pits for storage units against flooding and surface drainage, and point of discharge of drains therefrom.

7. Type of cover or roof, manholes, vents, overflows, control gages, and character of pipe connections to reservoir with regard to danger of leakage at points of entry.

8. Disinfection practice of new reservoirs or after cleaning and repairs on existing units.

Examples of Sanitary Defects:

1. Presence of earth formations at the reservoir site such as limestone, broken lava rock, coarse gravel, etc., whose interstices are in the form of channels, joints, or fissures and hence provide too little filtering action to prevent contamination from reaching the reservoir; poor surface-drainage conditions; insufficient distance from bodies of surface water or sources of contamination; top of reservoir not above ground or above level of flood waters.

2. Unsatisfactory materials, poor state of repair, cracks, lack of proper cover; vents and overflows that do not exclude birds, dust, rain, insects, etc.

3. Water-level indicators and control gages that permit entrance of contamination into stored water.

4. Curbing or roof coping interfering with roof drainage.

5. Man holes and covers of flush type, and covers or manholes which permit leakage of drainage into the reservoir or storage unit.

6. Drains from reservoirs to sewers or surface waters when backflow therefrom can reach reservoir.

7. Valve stems projecting through reservoir covers not protected.

Recommended Sanitary Requirements for Water Treatment Systems

A. General Requirements

1. Extent of Treatment. For purposes of classification with respect to treatment requirements, waters acceptable for treatment may be divided into four groups. For practical purposes coliform bacterial content of the raw water can be expressed either in terms of "most probable number" or "Phelps Index" without changing the limiting coliform averages indicated for the various water groups. (See Public Health Reports Reprint No. 1170, July 15, 1927, pp. 7-11 and 18-19.)

Group 1. Water Requiring No Treatment. This group is limited to underground waters not subject to any possibility of contamination, and meeting, in all respects, the requirements of the Public Health Service Drinking Water Standards, as shown by satisfactory, regular, and frequent sanitary inspections and laboratory tests.

Group II. Waters Requiring Simple Chlorination, or Its Equivalent. This group includes both underground and surface waters subject to a low degree of contamination, and meeting the

requirements of the Public Health Service Drinking Water Standards in all respects except as to coliform bacterial content, which should average not more than 50 per 100 ml., in any month.

Group III. Waters Requiring Complete Rapid-Sand Filtration Treatment, or Its Equivalent, Together with Continuous Postchlorination. This group includes all waters requiring filtration treatment for turbidity and color removal; waters of high or variable chlorine demand; and waters polluted by sewage to such an extent as to be inadmissible to groups I and II, but containing numbers of coliform bacteria averaging not more than 5,000 per 100 ml. in any one month and exceeding this number in not more than 20 percent of the samples examined in any one month.

Group IV. Waters Requiring Auxiliary Treatment in Addition to Complete Filtration Treatment and Postchlorination. This group includes waters meeting the requirements of Group III with respect to the limiting monthly average coliform numbers, but showing numbers of coliform bacteria exceeding 5,000 per 100 ml. in more than 20 percent of the samples examined during any one month and not exceeding 20,000 per 100 ml. in more than 5 percent of the samples examined during any one month.

Note. "Auxiliary treatment" as used here is presedimentation or prechlorination, or their equivalents, either separately or combined, as may be necessary. Long-time storage, for periods of 30 days or more, represents a permanent and reliable safeguard which in many cases would provide something more than an effective substitute for one or both of the two other methods indicated.

Remarks.

(a) Although Group I conceivably might include exceptional surface waters free of any possible contamination and further protected by storage, it hardly may be considered as a safe general rule to admit any surface water to a public supply without chlorination as minimum safeguarding treatment, in view of the present increased hazards of chance contamination resulting from the extension of recreational and migratory travel to many hitherto inaccessible places.

(b) The limiting monthly average coliform numbers stated for waters of Group II and III are intended as guides rather than inflexible rules, though they are based on extensive observational data fairly representing present water-treatment practice in this country. Consideration should be given to all aspects of the character and quality of the raw water; its range and suddenness of fluctuation in concentration of constituents which would influence the efficiency of the water-treatment process; the size and the complexity of the water-treatment plant, and the type of supervision provided, in addition to the bacteriological characteristics of the raw water. Certain recent improvements in water chlorination and its control offer promise of increasing the margin of safety of water-purification efficiency, with respect to bacterial removal. These improvements have not become fully incorporated into general practice throughout the country, and they should not be regarded as warranting any relaxation in the requirements for raw-water quality which experience and present standards of safety indicate as being necessary for providing adequate protection to sources of water supply in general.

(c) For waters of Group IV, which differ from those of Group III only in respect to variability, auxiliary treatment is intended mainly as a factor of safety in controlling variations in coliform number within the range of 5,000 to 20,000 bacteria per 100 ml. The larger of these two figures represents the maximum safe limit for prechlorination, or its equivalent, in addition to filtration treatment and post-chlorination.

(d) Waters failing to meet the requirements of Groups I, II, III, or IV are considered as unsuitable for use as a source of water supply, unless they can be brought into conformance with these requirements by means of prolonged preliminary storage, or some other measure of equal permanence and reliability.

2. Other Raw Water Requirements. Waters acceptable for treatment, in addition to meeting the aforesaid bacterial requirements, should not contain any toxic, taste-producing, or otherwise harmful substances, or organisms, not readily and completely removable by ordinary water treatment. Raw waters should be free of excessive amounts of acid, microscopic organisms, and organic matters causing any interference with the normal operation and efficiency of water-treatment processes.

B. Design and Construction.

In general, the design and construction of individual water-treatment plants will vary with local circumstances and should be in accord with the results of experiments on the water to be treated. The following recommendations are intended only as a general guide to good practice and are to be interpreted somewhat broadly in the light of the particular raw-water characteristics and other conditions which may be involved in a given situation.

1. Plant Delivery Capacity. The delivery capacity of a treatment plant, including filtered-water storage at the plant, should always be in excess of the maximum expected draft on any day of the year. The ratio of maximum day draft to the average day draft varies considerably with the nature of the particular community, hence an evaluation of the adequacy of the delivery capacity of a treatment plant should be based on a study of the maximum expected draft on any day of the year, having regard to past experience and making allowance for future conditions and growth of the community. The plant should be able to meet the maximum daily draft to be expected some years in the future. Plant expansion is indicated when the maximum expected draft, 4 or 5 years in the future, approximates the present delivery capacity of the treatment plant.

2. Plant Location. The plant should be located so that no conduit, basin or other structure containing or conducting water in the process of treatment can possibly be affected by leakage from any sewer, drain or other source of contamination. If located in a valley, the site should be adequately drained so that no surface water can gain access to wells, basins, filter tanks or other units.

The water-treatment plant preferably should have greater protection than, and at least as much protection against floods as the community it serves. This protection against floods may be provided by locating the plant on high ground above flood levels, by construction of levees, by installation of vertical centrifugal pumps with motors situated above high water level, etc. The adequacy of flood protection should be judged with regard to the flood heights to be expected, the structural soundness of the protective works, and the availability of sufficient auxiliary power and pumping equipment to assure the continual operation of pumps for the removal of flood waters under emergency conditions.

3. Presettling Reservoirs. The term "presettling reservoirs," as used here, denotes reservoirs used for the removal of turbidity by plain sedimentation, supplemented in special cases by the addition of coagulants and/or chlorine. The term does not include the relatively small, so-called "grit reservoirs," commonly used in the Mississippi Valley for the removal of coarse silt and sand, rather than for the deposition of the finer clay particles.

Presettling reservoirs, if used, should be located above the influence of flood waters. They should be at least two in number, so as to permit continuous operation under all circumstances, and should be of sufficient capacity to afford a nominal retention period of at least 1 day and preferably 2 or 3 days. Provision should be made for rapid and convenient removal of sludge from the reservoirs. In the treatment of highly polluted waters of variable quality, provision should be made for coagulation at the inlet and for prechlorination at the inlet or the outlet of the reservoirs, whenever such measures may be necessary. Reservoirs should be provided with boats and life preservers for the protection of employees.

4. Coagulation Sedimentation Basins. In order to insure continuous operation, basins for flocculation and sedimentation of coagulated waters should be at least two in number. The basins should be designed for operation in series or in parallel and preferably should provide a total retention period of at least 5 to 6 hours, except in the case of preliminary mixing and flocculating devices and continuous sludge removal, permitting somewhat lower periods with unimpaired efficiency.

With the well-designed basins of the conventional type, handling a well-coagulated water, a 2 to 4 hours theoretical retention period may be sufficient for preparation of the water for filtering. Inlets and outlets of ordinary straight-flow basins should be provided with baffles to "kill" the velocity at the inlet and be so located as to prevent short-circuiting. The maximum velocity of flow in the settling compartment should not exceed that which usually is provided in well-designed

basins of this type. The length of settling compartments in such basins, if rectangular, preferably should be at least twice the width. Stilling compartments should be provided at basin inlets. If stream use will permit, sludge drains may discharge at points located well downstream from the intakes, at points removed from the influence of cross-currents passing the intake. Otherwise, suitable sludge-disposal areas should be provided. The depth of basins should be such as to maintain velocity of flow and sludge removal, the permissible depth being slightly lower with continuous sludge removal. Flow-line elevations should not vary more than a few inches above or below the normal level.

Coagulation and sedimentation plants of the sludge blanket type have been used sucessfully with various types of raw waters in a number of plants built in recent years. When the chemical and physical reactions in plants of this kind produce a floc with good settling properties, retention periods of an hour or less are sometimes permissible. Evaluation of plants of this type should be based on performance and operating results for existing installations; for proposed installations, experience with waters of similar character in other plants of this type should be reviewed.

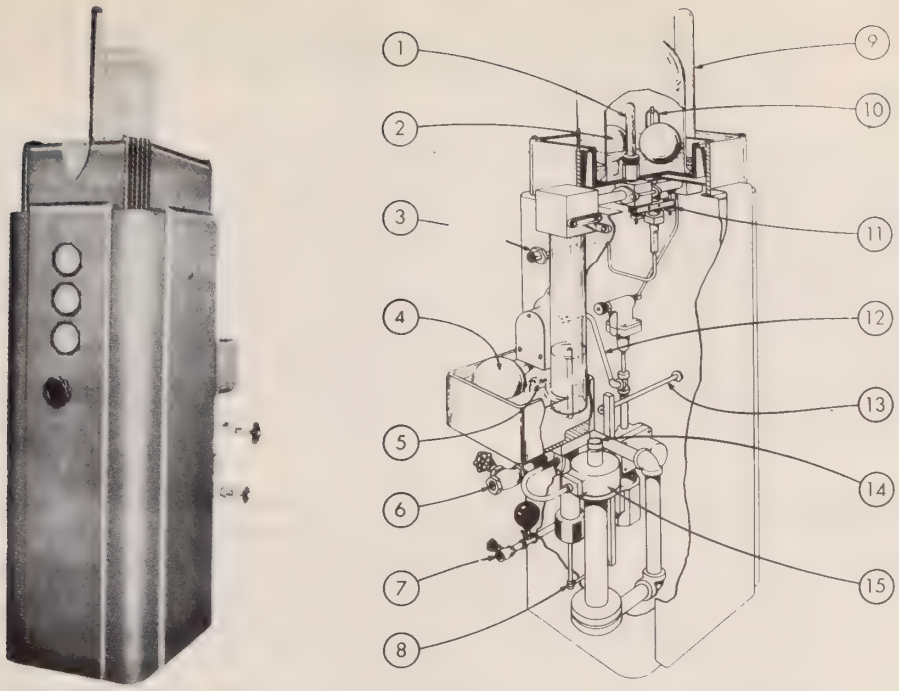
Preliminary flash-mixing and flocculating equipment capable of adequate flexibility of adjustment to provide optimum flocculation under varying raw-water conditions is a desirable feature of well-designed, modern filtration plants and should be credited as a distinct addition to the sanitary protection afforded by a purification system. An ideal combination of flash mixing and flocculation should provide about 1 to 2 minutes of violent agitation followed by about 20 to 30 minutes of slow mixing to promote flocculation.

5. Coagulant System. Rapid-sand filtration plants should be provided with efficient modern devices for measuring and adding coagulants to the water under treatment. All chemical dosing equipment, whether of the dry-feed or solution-feed type, should have at least one unit in reserve throughout and should be provided with effective recording and alarm devices to ensure continuity of service at all times. An accurate flow meter should be provided for the water treated. Suitable gravimetric devices for measuring the amount of chemicals added from hour to hour should be provided for dry-feed equipment. Provision should also be made for checking the quantity of chemicals added by solution feed equipment. Recording devices may be installed on feeding weirs or on batch supply tanks, or the solution supply tanks may be installed on scales to permit gravimetric determination of feed rates. All chemical feed equipment should be capable of ready adjustment to variations in the flow of water being treated.

6. Filters: Slow-Sand. Slow-sand filters, if properly designed and operated, are applicable to the treatment of certain types of relatively clear waters. Preferably they should be covered; provided with loss-of-head gages; have a sand depth of 36 to 40 inches; and never be operated with less than 20 inches of depth. The sand should have an effective size of preferably 0.25 to 0.35 millimeters and filters should be operated at rates of about 2.5 million gallons per acre daily. In operating slow-sand filters care should be taken to avoid any sudden increases in the rate of filtration. The filter area should be provided in several independent units so that the quantity of water required at times of maximum draft can be supplied when some units are out of service for cleaning or repair work.

Preliminary treatment of water applied to slow-sand filters is sometimes provided. Such treatment may consist of simple sedimentation; sedimentation proceded by coagulation; preliminary rapid filtration with or without coagulation and sedimentation. In these cases the objective is to condition the raw water, particularly with respect to the removal of turbidity, for more efficient or satisfactory treatment in the slow-sand filters. Depending upon the degree of preliminary treatment provided, the filtration rates for slow-sand filters may be appreciably increased. Under these circumstances, the conventional daily rate of 2.5 million gallons per acre may be doubled or even tripled.

7. Filters: Rapid-Sand. Rapid-sand filters should be preferably of the open gravity type, in order to permit ready and continuous inspection. Pressure filters are not recommended for the filtration of polluted waters; however, they do have a proper use in zeolite softeners. The depth, effective size, and uniformity coefficient of the sand should be in accordance with the requirements of adequate yield and filter efficiency. Sand depths of about 30 inches are recommended, with an effective sand size ranging from 0.40 to 0.50 millimeters and a uniformity



1. Chlorine meter
2. Air relief vent
3. Chlorine gas inlet
4. Float control
5. Overflow
6. Main water supply to injector
7. Auxiliary water supply to trays
8. Adjustable riser
9. Rate of feed indicator
10. Float operated chlorine inlet valve
11. Tray water supply
12. Water to auxiliary tray
13. Feed adjuster
14. Chlorine solution discharge
15. Injector assembly

Fig. 20 Wallace and Tiernan Manual Control Vacuum Chlorinator with Orifice Feed Indicator and Variable Vacuum Feed Control

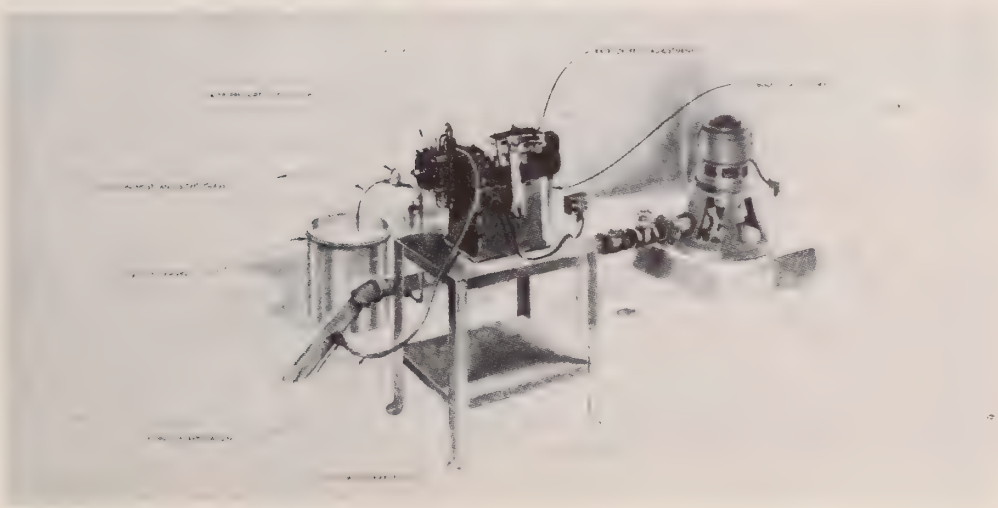


Fig. 21 Hypochlorinator Installation
The hypochlorinator is connected to the discharge (pressure) line of the pump. The type of instrument shown here has a second connection with the line to balance the diaphragm.

coefficient from 1.5 to 2.0. However, sands of other characteristics than these may be used successfully, depending on local conditions, plant design, and characteristics of the water. The rate of filtration should conform to established practice, preferably not exceeding 3 gallons per minute per square foot of filtering area.

In general, rapid-sand filters should be designed and operated with a view to maintaining reasonably high efficiency of bacterial removal, and keeping the filtering medium in good condition, free of mud balls, cracks and other hindrances to efficient filtration. Present design practice indicates that backwash facilities should be available to provide an adequate quantity of water at a rate sufficient to provide a 50 percent increase or expansion of the sand depth. Suitable surface-wash equipment is useful in maintaining filter efficiency where there is a tendency to formation of mud balls. Efficient loss-of-head gages, rate controllers and other essential control devices should be provided. The filter area should be provided in several independent units so that the quantity of water required at times of maximum draft can be supplied when some units are out of service for cleaning or repair work.

8. Filtered-Water Storage Reservoirs. Filtered-water reservoirs at the plant preferably should be covered and located near to, but physically separated from, the plant. However, where such reservoirs are located below filters, adequate protection against leakage of drainage water from other parts of the plant into the reservoirs should be provided. Trap doors and inspection openings should be properly sealed and locked. Suitable vents, protected against outside contamination, should be provided. All effluent pipes should be properly sealed against leakage and tested by frequent inspections. Filtered-water reservoirs should be thoroughly tight against external leakage; if practicable, be situated above the ground water table; and preferably should have no single walls in common with any other plant units containing water in a prior stage of treatment.

9. Cross Connections, Open Connections and Partition Walls. (See D under Recommended General Sanitary Requirements for Water-Distribution System).

a. No cross-connection should be permitted to exist in a filtration plant between any conduit carrying filtered or postchlorinated water, and another conduit carrying raw water, or water in any prior stage of treatment.

b. No conduit or basin containing finished water should be permitted to have a common division wall with another conduit or basin containing raw water or water in any prior stage of treatment.

c. Rewash or filter-to-waste conduits should not be directly connected to any drainage conduit, but should be protected by a suitable one-way, air-gap-delivery connection, to ensure that no back-flow can occur under any condition.

d. No conduit carrying raw water, nor any water in a prior stage of treatment, should be located directly above another conduit carrying finished water, with a single, common partition between them. This rule is not strictly applicable where the water in a prior stage of treatment is conveyed in a cast iron or other equally durable and impervious pipe with tight joints, and is located where it is readily accessible for inspection and repair.

10. Drains. All drainage conduits should be constructed so as to be thoroughly tight against external leakage. They should discharge at points in a river or lake so located that no currents of water can, under any circumstances, be carried from a drain outlet to the plant intake, or to any other water intake located in the vicinity of the plant. No domestic, or other, sewer should be permitted to be discharged into a river or lake in the vicinity of a treatment-plant intake, or directly above such intake; nor should any drain carrying contaminated surface water to be permitted to be discharged likewise.

11. Chlorination.

a. General. Chlorination equipment should be selected, installed, and operated that continuous and effective disinfection is secured under required local conditions. (Fig. 20, 21, 22)

b. Chlorination Equipment.

(1) chlorination equipment should be installed so as to provide sufficient stand-by units for insuring uninterrupted operation. The capacity of chlorination equipment should exceed the highest expected dosage to be applied so as not to require use of stand-by equipment for normal operation. The determination of the highest expected dosage should be made under the approval

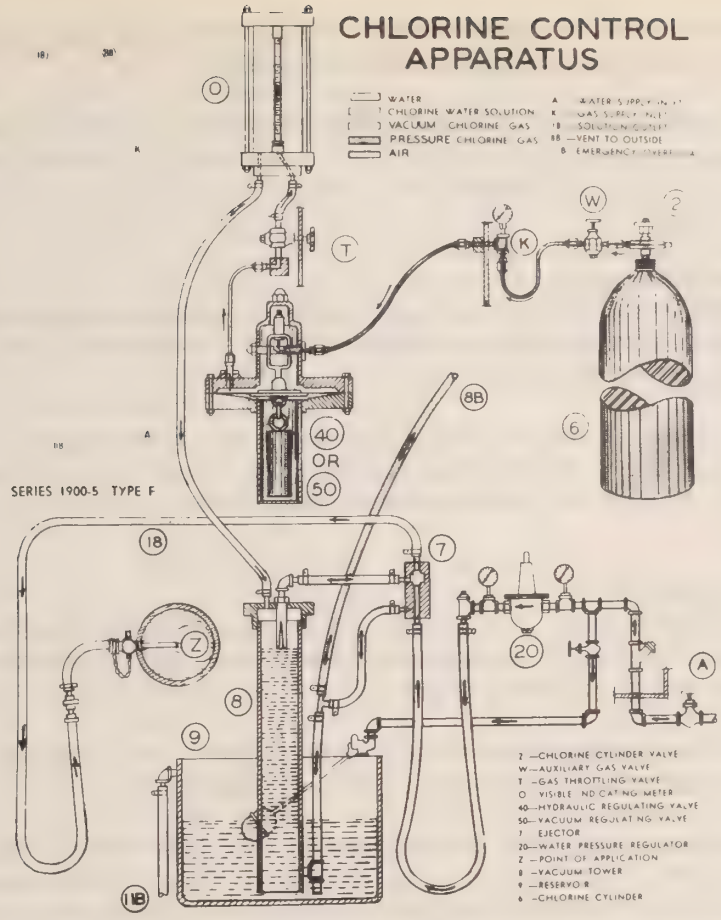


Fig. 22 Everson Manual Control Vacuum Chlorinator with Rotameter (Spinning Top) Feed Indicator and Gas Throttling Valve.

of the supervising agency, as the Public Health Service, the State department of health, etc., with due regard to the characteristics of the water to be treated and the treatment involved e.g., breakpoint, free chlorine, chloramine, etc. Stand-by units should be operated frequently to insure workability. A complete stock of spare parts and tools should be maintained for emergency replacements or repairs. Chlorination equipment should be capable of satisfactory operation under every prevailing hydraulic condition at the plant.

(2) Automatic proportioning of the chlorine dosage to the rate of flow of the water treated should be provided at the larger plants and, in general, at all plants where the rate of flow varies more than 50 percent above or below the average flow. In the latter case and where the water being chlorinated is pumped by manually controlled pumps, manual adjustment of the chlorine dosage is permissible provided the certainty of making necessary changes in the chlorine dosage with changes in the pumping rates is assured. Manual control of the chlorine dosage is generally permissible where the rate of flow is relatively constant and an attendant is always on hand to effect promptly the necessary adjustments in dosage. Automatic proportioning of the chlorine dosage to the chlorine demand of the water is also desirable, particularly where the quality of the water is subject to change without warning.

(3) A reliable and uninterrupted supply of water, free of coarse suspended matter, should be available under adequate pressure to ensure the continuous operation of solution-feed chlorinators. Hydraulically or electrically-driven pumping equipment, if used for maintaining such pressure, should be provided with alternative sources of power where needed to ensure continuous operation.

(4) Scales, preferably of the indicating and recording type, should be provided for weighing the cylinders of chlorine and checking the losses in weight of chlorine as fed from the

cylinders during successive intervals of time. These scales should be sufficiently accurate and sensitive to measure such losses with suitable precision.

(5) A sufficient number of cylinders of chlorine should be connected to the chlorinator in use so that adequate operating pressures are maintained at various temperatures, and sufficient reserve supply of chlorine should be on hand at all times to assure continuous chlorination of the water.

c. Hypochlorite Solutions.

(1) Solutions of calcium or sodium hypochlorite should be prepared in a separate mixing tank, then diluted and allowed to settle, so that only a clear supernatant liquid is withdrawn to the solution storage tank and to the chlorinator.

(2) The strength of stored calcium-hypochlorite solutions should be checked frequently by laboratory test in order to ensure that no loss of strength has occurred. Fresh calcium-hypochlorite solutions should be prepared every 4 or 5 days, unless properly alkalinized with sodium carbonate.

d. Safety Requirements.

(1) Suitable gas masks and a small bottle of ammonia to test for leaks should be kept at convenient points immediately outside the room or enclosures in which chlorine is being stored or is in use. Gas masks should be inspected at regular intervals and kept in serviceable condition.

(2) Chlorinating equipment and cylinders of chlorine preferably should be housed in separate buildings above the ground level as a measure of safety.

(3) The room, or building, housing chlorinators in service, should be maintained at a temperature above 60°F., but never in excess of the normal summer temperature of the atmosphere. The cylinders of chlorine should be shielded, where necessary, from excessive heat or cold. Neither direct heat nor hot water should be applied to cylinders of chlorine, nor to the cylinder valves.

(4) Adequate ventilation should be provided for all enclosures in which chlorine is being fed or stored.

(5) All joints of tubing connecting chlorine cylinders and chlorinators should be kept absolutely tight, and should be inspected frequently to ensure tightness. Tubing should slope upward from the cylinders.

e. Control of Chlorination.

(1) Chlorine should be applied continuously to the filtered effluent at a point where thorough and rapid mixing with the treated water is effected. Free active chlorine should be in contact with the treated water for not less than 20 minutes; or chloramine preferably for at least 3 hours, before the treated water reaches the first consumer.

(2) The proper dosage of chlorine will be determined by regular and frequent routine bacteriological and residual-chlorine tests, both at the plant and at various points in the distribution system. In general, a safe and desirable minimum of residual free chlorine at distant points in the distribution system is 0.05 or 0.10 p.p.m., depending on the pH and temperature of the water (tables 12 and 13). For chloramines, the desirable residual is 1.0 to 2.0 p.p.m. The residual chlorine carried in the finished water as delivered from the treatment plant should be regulated accordingly. At times of threatened, or prevalent, outbreaks of water-borne disease, the residual chlorine should be maintained preferably at a minimum of 0.1 p.p.m. for free chlorine and 2.0 p.p.m. for chloramine, in all parts of the distribution system, regardless of tastes or odors in the delivered water. Similar measures should be taken in the event of any lapse in the normal efficiency of the treatment plant.

(3) Routine sampling points should be maintained at the treatment plant and at several vital points in the water-distribution system. Sample collections should be made regularly at the latter points and tested for bacteria and for residual chlorine. Chlorine-demand tests should be

made occasionally on samples collected in the distribution system, for comparison with the results of similar tests at the treatment plant. Any abnormal increase in the chlorine demand, or decrease in the residual chlorine, at any point in the distribution system should be checked and, if consistently observed, followed up by a thorough physical investigation of that portion of the system.

(4) The tests for residual chlorine should be made in accordance with the current edition of the Standard Methods for Examination of Water and Sewage published jointly by the American Public Health Association and the American Water Works Association. A distinction should be made between residuals existing as free chlorine and as chloramines. Several methods for this differentiation are available. Such tests should be made at least once during each successive period of 8 hours every day in the finished water at the treatment plant and at least three weekly at regular sampling points in the distribution system.

(5) Special care should be taken to maintain a detailed and accurate record of chlorination and the results thereof. Such a record should show:

(a) Rate of flow of water treated.
(b) Gross weight of chlorine cylinder in use.
(c) Weight of chlorine used for 24 hours.
(d) Setting of chlorinator
(e) Time of making and results of residual chlorine test.

(6) As a guide to plant operators, it is recommended that unless bacteriological and other tests indicate the need of maintaining higher minimum concentrations of residual chlorine, at least 0.2 p.p.m. of free chlorine should be maintained in the treated water after a contact period of at least 20 minutes in the distribution system beyond the point of chlorine application. When chloramine treatment is used for disinfection, the residual-chlorine concentration as indicated by the orthotolidine reagent should be similarly at least 2.0 p.p.m. after 3 hours of contact, and 1.0 to 2.0 p.p.m. at all points in the distribution system. Where "break-point" chlorination is practiced, a sufficient concentration of residual free chlorine should be maintained at the treatment plant so that it will be not less than 0.05 to 0.10 p.p.m. at all points in the distribution system. When required in specific instances, the minimum concentration of residual chlorine and the minimum retention period for the chlorinated water should be increased as directed by the state department of health.

(7) Recent studies conducted by the Public Health Service indicate that:

(a) For a given contact period, and depending upon the pH and temperature of the water being treated, the ratio of chloramine to chlorine necessary to obtain a 100 percent kill of Escherichia coli is approximately 25:1 and will vary from 10:1 to 60:1.

(b) To obtain a 100 percent kill of Esch. coli at 2° to 5° C., it requires a contact period 1 to 10 times longer (average 3 times) than is required at 20° to 25° C. depending upon the pH of the water, when free chlorine is used at a given residual. When chloramine is used, a contact period 1 to 18 times longer (average 9) is required at the lower temperature.

(c) To obtain a 100 percent kill of Esch. coli at 2° to 5° C., it requires 1 to 7 times (average 4) as much free chlorine for the same period of contact as is required at 20° to 25° C., depending upon the pH of the water. When chloramine is used, 1 to 4 times (average 2.5) as much residual chlorine is required at the lower temperature.

Table 12. - Free Chlorine. Lowest chlorine residuals producing a 100 percent kill of "Escherichia coli" for contact periods and temperatures indicated at various pH values

pH	2° to 5° C.			20° to 25° C.		
	10 minutes	20 minutes	60 minutes	10 minutes	20 minutes	60 minutes
7.0	0.03	0.03	0.03	0.04	0.04	0.04
8.5	.14	.07	.05	.07	.07	.05
9.8	.72	.40	.40	.30	.06	.06
10.7	> 1.00	> 1.00	.30	.40	.30	.03

Table 13. - Chloramine. Lowest chlorine residual producing a 100 percent kill of "Escherichia coli" for contact periods and temperatures indicated at various pH values

pH	2° to 5° C.				pH	20° to 25° C.		
	40 min.	60 min.	90 min.	120 min.		10 min.	20 min.	60 min.
					6.5	1.50	0.90	0.30
7.0	1.80	1.50	1.20	0.90	7.0	1.80	1.20	.60
					7.8	> 1.80	1.50	.90
8.5	1.80	1.80	1.80	1.80	8.5	> 1.80	1.80	1.20
9.5	> 1.80	> 1.80	1.80	1.80	9.5	1.80	1.80	1.50
					10.5	> 1.80	> 1.80	1.80

It should be clearly understood that the data presented in Table 12 for free chlorine are applicable only when the residual is present as free chlorine to the absolute exclusion of chlorine-addition products (chloramines, etc.). As indicated by the data in Table 13, the bacterial death rate with chlorine-addition products (chloramine) is markedly less than that with free chlorine.

The ratio of chlorine to nitrogen in the case of chloramines had no effect upon the bactericidal action of chloramine until this ratio approached 10 to 1. When the chlorine is present in such amounts, a certain quantity may be present as free chlorine rather than as mono- or di-chloramine and this free chlorine, as already indicated, acts on the bacteria much more rapidly than the chloramines.

C. Operation Control

1. Supervision. Every water-treatment plant engaged in purifying water for domestic use should be under the charge of a technically trained supervisor. For plants treating variable or highly polluted raw waters, there should be continuous full-time trained supervision. For certain types of small plants, part-time trained supervision may be practicable under favorable circumstances. Under these conditions, the supervisor should be in constant touch with the plant attendants and available on call in any emergency, and should visit the plant at least twice each week.

2. Laboratory Tests and Control.

a. The schedule of laboratory tests followed in controlling the operation of a water-treatment plant will vary with the size of the plant and the character of the water treated, though certain minimum requirements may be stated. For the ordinary plant, the minimum schedule of laboratory tests should include determinations of air and water temperature, turbidity or color (or both), alkalinity, pH value, hardness, residual chlorine, bacterial count at 20° C. or 37° C. (or both), and coliform bacterial numbers, both presumptive and confirmed. Where "breakpoint" chlorination is practiced, a continuous record of free ammonia in the water to be chlorinated should be maintained. Occasionally special tests may be necessary, such as for residual alum, iron, manganese, taste and odor, or other undesirable constituents of the final effluent. Where prechlorination is used in addition to postchlorination, tests for residual chlorine should be made at each major stage of treatment and, in the raw water, tests for chlorine demand should also be made.

b. For operation control at the plant, the frequency of tests, particularly for turbidity, residual chlorine, bacterial count and coliform organisms though dependent on the character of the water treated and on its variability, should be such that at least one test every 24 hours, on each day of the week, is carried out. For the larger plants, at least three sets of samples should be collected daily for bacteriological tests. Determininations of turbidity and residual chlorine should be made more frequently, sometimes at hourly intervals when the character of the raw or partly treated water is changing rapidly.[1]

1. The following rule, wholly arbitrary, would give sampling frequencies depending in part on the daily volume of water treated and on the density of raw water pollution:

$$N = \sqrt[3]{VC}$$

N = Number of samples per 24 hours
V = Volume of water treated in million gallons daily
C = Coliform number, M. P. N., in thousands per 100 ml.

According to this rule, the number of samples per 24 hrs. would range from 1 to 2 for a 1 m. g. d. plant with a raw-water coliform number of 1 to 5 thousand per 100 ml., and from 5 to 8 for a 100 m. g. d. plant with the same range in coliform numbers.

c. An important, though somewhat less tangible element in judging the efficiency of plant operation is the general appearance of the plant and its surroundings. A neat well-kept plant with attractive grounds is almost invariably an index of efficient operation, although in some of the smaller plants, this criterion may not always be infallible. Mere neatness in external maintenance of a plant, however, cannot offset lack of proper training on the part of the operator.

In rating the general efficiency of operation control, the following items are of primary importance:

(1) Training and experience of supervisor and operating staff.
(2) Adequacy of operation records.
(3) Efficiency of laboratory control.
(4) Suitability of plant design and construction to the character and pollution of the raw water.
(5) Capacity of the plant in relation to the average and maximum required output.

Recommended General Sanitary Requirements for Water-Distribution Systems

A. General

1. A water-distribution system should be designed and constructed so as to provide, at all times, an adequate supply of water, at ample pressure, in all parts of the system.

2. The safety and palatability of the water should not be impaired in any manner while flowing through the distribution system, or any part thereof.

3. The system should be provided with sufficient valves and blow-offs so that necessary repairs can be made without undue interruption of service over any considerable area. Blow-off connections to sewers should be prohibited. In level terrain this may require provisions for dewatering of blow-off manholes with pumps.

4. No unprotected open reservoir, or physical cross-connection whereby unsafe water can enter the distribution system, should be permitted.

5. The system should be tight against excessive leakage and its various mains and branches should be separated from rivers and other possible sources of contamination.

6. The system should be designed so as to afford effective circulation of water, with a minimum of dead ends.

7. The distribution system should be maintained in a sanitary manner, with due precautions against contamination of the water in any part of it as the result of necessary repairs, replacements or extension of mains.

8. Frequent and regular bacteriological examinations should be made of water samples collected at various control points in the distribution system, with an immediate and thorough checking of any unusual results.

B. Piping System

1. The piping system should be designed to maintain an adequate positive pressure of water in all parts of the system, with due regard to unusual drafts on any part of the system. Water mains should be of adequate size, and pressure-equalizing stand-pipes or reservoirs should be located at suitably distant points from the pumping or main supply station.

2. Joints should be of such design and installation that leakage, evaluated on a pressure basis of 150 pounds per square inch, is less than 100 gallons per 24 hours, per mile of pipe, per inch of nominal diameter. Materials used for caulking should be of such a character as not to foster the growth of coliform bacteria and should be free from oil, tar, and/or greasy substances.

3. Corrective water treatment should be instituted where deposits in the mains tend to reduce the effective size and capacity of the pipes. For biological deposits, heavy chlorination may be effective.

4. Where dead ends are necessary as a stage in the growth of the system, they should be located and arranged with a view to connecting them ultimately so as to provide circulation.

5. Many crossings of water pipes and sewers cannot be prevented, except at an appreciably increased cost in the provision of these facilities. On the other hand, potential health hazards come about because of such crossings, particularly when the sewer is at a higher elevation than the water pipe. Leaks may occur in both water and sewer pipes because of improperly constructed joints, corrosive action of soils and water, settling of soils around these pipes, etc. Under the circumstances, sewage contamination may enter the water pipes, depending upon the pressure conditions in them; the extent of sewage leakage; and the nature of soil formations. Accordingly, it is recommended that water pipes be laid, so far as possible, at an elevation above that of nearby sewers. Where this cannot be done because of topography or other controlling conditions, extra

care should be taken to install pipe of durable and corrosion resistant material with tight, durable joints in both the water pipes and sewers. Similar precautions should be taken with respect to water-service lines.

6. When nonferrous metal pipe is to be used for water-service lines, consideration should be given to the corrosive effects of the particular water on the metal to be used, in view of possible development of deleterious physiological effects upon consumers, resulting from solution of the metal.

7. Due sanitary precautions should be taken in laying new water pipes. Where avoidable, pipe should not be laid in water nor where it can be flooded with water or sewage in the laying process. Leakage tests should be made by means of hydrostatic pressure. New mains should be kept filled with a strong hypochlorite or chlorine solution (40-60 p. p. m. of chlorine) for at least 24 hours, and then drained before being placed in service. Fire hydrants should not be drained into sewers or storm drains. Valve chambers should be of water-tight construction and should not be connected directly to a storm or sanitary sewer.

C. Storage

1. There should be sufficient capacity in the system to assure, at all times, an adequate supply of water at ample pressure in all parts of the system. Consideration should be given to the storage or reserve requirements for emergency use, as for fire fighting, and in meeting the drain caused by a break in a large water main.

2. Preferably, storage reservoirs should be located above ground-water level and in such a location that surface water and underground drainage is away from the structures. Provisions should be included to guard against the sanitary hazards related to location factors such as ground-water levels, movements and quality, character of soil, possibility of sewage pollution, and over-topping by floods. Sites in ravines or low areas subject to periodic flooding should be avoided. Any sewer located within 50 feet of a storage reservoir should be constructed of extra heavy cast-iron pipe with tested watertight joints.

3. All storage reservoirs should be protected against flood waters or a high water level in any stream, lake, or other body of water. If practicable, the reservoir should be placed above water level. The structure and appurtenances should be constructed so as to be watertight.

4. The ground surface about the reservoir should be sloped so as to drain or divert surface water away from the reservoir and should be so graded that no pooling of surface water will occur within the vicinity of the reservoir.

5. Any overflow, blow-off, or clean-out pipes from storage reservoirs should discharge freely into an open basin from a point not less than two diameters of the discharge pipe above the top or spill line of such receiving basin. If such drainage pipes be at any time likely to be submerged by surface or flood waters, they should be provided with double check valves to guard against backflow of contaminated water into the reservoir. If the receiving basin be so located as to overflow above the ground level it may be drained into a storm sewer; otherwise it should be drained by a reliable drainage pump. All overflow, flow-off, or clean-out pipes should be turned downward and screened with removable 24-mesh screen to prevent the entrance of rain, dust, birds, insects, rodents, and other contaminating materials.

6. All inlet and outlet pipes connecting to storage reservoirs should be properly supported and constructed so as to minimize settling, and the wall castings should be provided with suitable collars to ensure a watertight connection.

7. A suitable and substantial cover should be provided for any reservoir, elevated tank, or other structure used for water storage. Covers should be watertight, of permanent material, and constructed so as to provide drainage away from the cover and prevent entrance of contamination into the stored water. The surface of covers on storage reservoirs should not be used for any purpose in connection with which contaminating matter is likely to be produced.

8. Manholes and manhole covers, where necessary on covers over storage reservoirs, should be fitted with raised watertight walls projecting at least 6 inches above the level of the surrounding concrete surface. Each manhole frame should be closed with a solid watertight cover, preferably with edges projecting downward at least 2 inches around the outside of the frame. The manhole covers should be kept locked at all times except when actually in use.

9. Any necessary vents or openings through covers on storage reservoirs, for water-level control gages or other purposes, should be constructed so as to prevent the entrance of dust, rain, snow, birds, insects, or any other materials which might include contamination.

10. Storage reservoirs should be operated at all times in such a manner as to maintain the

highest sanitary quality of the water.

D. Interconnections, Backflow Connections, Cross and Open Connections

Definitions*

(1) Cross-connection - Any physical connection or arrangement of pipes between two otherwise separate water-supply systems, one of which contains potable water and the other water of unknown or questionable safety, whereby water may flow from one system to the other, the direction of flow depending upon the pressure differential between the two systems.

(2) Open connection - A piping arrangement which provides an air gap between two water-supply systems and which may become a cross-connection or interconnection by the insertion of a length of pipe into the air gap.

(3) Backflow connection - Any arrangement whereby the flow of water or other liquids into the distribution system of a potable supply of water can occur from any source or sources other than its intended source.

(4) Interconnection - A physical connection between two potable water-supply systems.

1. In general, no physical cross-connection should be permitted between a public or private water-distribution system containing potable water, and any other system containing water of questionable quality, or any other contaminating or polluting substance.

2. Open connections, physically separated, may be permissible under regulation and supervision by the local, or State health department.

3. House or industrial toilet or sink fixtures capable of back-siphonage into the water system should be classed as backflow connections and therefore be prohibited.

4. Interconnections may be permissible when approved by the State department of health.

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Inexpensive Emergency Chlorination Methods**

An inquiry sometime ago by the Training Center, Louisiana State Health Department showed that half of the State Health Departments issued literature on emergency chlorination equipment and half did not. A summary of the methods most widely used will be described. Although cheap methods of home-made chlorination may be set up in a few hours, it is much more desirable that water plants have more dependable apparatus available at all times for emergency use. Nevertheless, home-made apparatus can be extremely useful for even several months when necessary.

The conditions calling for installation of emergency chlorination equipment are:

1) Where water supplies or swimming pools normally have a chlorine residual available in all sections and where:

a) The chlorinator has become defective and requires unavailable repair parts or unavailable expert engineering attention.

b) The replacement of exhausted chlorine supply is delayed.

c) An increase in chlorine demand in excess of the chlorinator's capacity is required or where it would be unwise to depend solely on the chlorination of the discharge of the service pumps.

2) Where, in water systems, no chlorination is normally applied, or in sections of chlorinated supplies where residual cannot be maintained during a period of repair and where:

a) Cracks have developed in the walls, or bottom of a water reservoir, or the roof is not entirely water and insect tight, or is being repaired.

b) Underground valves not properly placed in waterproof boxes have leaking gaskets or underground suction pump lines have developed leaks.

c) Casings of tubular wells are leaking, or not deep or high enough, or open at top.

d) A new wood stave reservoir has been installed and has to be put in operation before bulk chlorination has been effective.

* A service connection is defined as a connection between a water line of a public or semi-public water system and the water piping system of a single premises usually joined by a valve and/or meter controlled by the water system management and located in a curb box or on the premises.

** Inexpensive Emergency Chlorination Equipment, J. A. K. van Hasselt. Proceedings of the 12th Annual Short Course for Water and Sewage Plant Superintendents and Operators, 1949; Baton Rouge, Louisiana.

e) Change in treatment such as added aeration, or iron removal by chlorination makes the installation of chlorination imperative, and a regular chlorinator is not yet available.

f) A new section of the water system has been laid with insufficiently sterilized hemp in the joints.

g) A section is being cleaned by a pressure scraper which has to be followed by chlorination.

h) A swimming pool, operated previously on the fill and draw system, is being equipped with a home-made recirculation and chlorination system, with the intention that future improvements have to be paid from the receipts.

i) Samples from a water supply repeatedly show contamination and the cause cannot be readily detected.

j) Samples from a water supply show no contamination, but a highly potential contamination hazard is found to exist and emergency chlorination needs to be applied until corrections are made.

Five types of chemical can be used for emergency chlorination:

1) Calcium hypochlorite powder, $Ca(ClO)_2$, must be mixed with water and forms a milky, turbid solution. This must be settled before being used. The commercial products come in 70%, 50%, and 15% strengths of available chlorine.

2) Sodium hypochlorite, NaOCl, is a clear liquid which may contain as high as 17% available chlorine. It contains no grit and is therefore ideal for home made apparatus. A 1% solution of NaOCl can be made up by dissolving 1.6 lbs. of chlorine gas, 2.5 lbs. of pure sodium hydroxide (or 2.75 lbs. of commercial lye, or 5.75 lbs. of sodium carbonate) in 10 gallons of water.

3) Chlorinated lime CaCl(OCl), or bleaching powder leaves heavy sediment and comes in strength of 25-35% active chlorine.

4) Chloramines or Chlorammonium combinations produce residuals of much greater stability but need a much longer retention period for equally effective sterilization.

5) Liquid chlorine comes in 5, 100, and 150 lbs. cylinders.

Desiderata that the equipment should fulfil:

1. Simplicity and economy of construction and operation.

2. It should be possible to regulate the flow within certain limits and with small changes, and once set, the flow should remain practically constant. This requires a constant head flow, the possibility to vary this head, and a sensitive faucet or other appliance making very small adjustments possible.

3. The apparatus should require a minimum of daily supervision. This means that, as a rule, the apparatus should be serviced and inspected not more than once, certainly not more than twice daily in small water supplies. This can be accomplished by the use of large enough vats and of sufficiently strong solutions of hypochlorite to treat one day's supply of water.

4. It should require a minimum of repairs which means that, within bounds of economy, the materials used should be those least corroded by the action of chlorine, such as hardwood, rubber, glass and plastics.

Choice and discussion of apparatus. The choice of apparatus will greatly depend upon available materials and the form of chlorine agent to be used in connection with the purpose and location of application. Important is also the amount of supervision the installation will need. Another consideration is that of safety of the apparatus, and (in case of the use of liquid chlorine) that of the operator. Finally, the matter of expense is often a deciding factor. It sometimes pays to have a more durable apparatus and use chlorine gas than to have a much lower first cost and use chemicals costing many times as much as gas. A brief description of various pieces of equipment which have given satisfaction in the past is given below.

1. The simplest apparatus, evidently, but the one least satisfying the second desideratum is a barrel provided with a faucet and filled with a chlorine solution over the point of application, the chlorine being applied by partly opening the valve. This method has two great disadvantages:

a) The only means of regulation is the setting of the valve. The amount of solution needed can be approximated first by calculation, then be determined by trial and error and the setting of the faucet marked for a certain strength of solution.

b) As the liquid level in the barrel is lowered, the rate of feed changes, since it varies with the square root of the distance of the liquid level above the faucet. For instance, when the

level difference is 36 inches, the discharge will be only 67% as much at a level difference of 16 inches; the result being a decrease of 33% of the chlorine residual of the water. This disadvantage can often be considerably reduced by applying the chlorine through a hose of small diameter reaching into the water to be chlorinated. If, for instance, the faucet to which this hose is attached be 45 inches above the water, the chlorine solution level in both cases will be respectively 81 and 61 inches above the water, making the discharge in the latter case 0.865 times that of the former case or only 13 1/2% less instead of 33% (Fig. 23). The higher the barrel is placed, the less therefore the influence of the variation in water level. The hose leading below the water level in that case, should contain no air, but be completely filled. The opening in the barrel should be a few inches above the bottom, to provide space for grit and other sediment, unless sodium hypochlorite be used. A hose connected with the city water line should be used to clean the barrel after each emptying, and to mix the hypochlorite in the barrel for the new batch. A plug in the bottom of the barrel will facilitate cleaning. A cover should be applied to prevent dilution by heavy rainfalls. In order to make resetting of the valve unnecessary, a clamp can be placed on the hose as low as possible which is tightened until the desired dosage is reached; the valve can then be closed for cleaning and refilling and no resetting is necessary.

2. An improvement on this equipment is the introduction of constant head flow. This can be realized in three different ways:

a. The use of a 5 or 10 gallon carboy, provided with a rubber stopper with 2 holes. The first hole contains a 1/4" glass tube descending within 1" from the bottom through which air enters the carboy; the second contains a 1/4" siphon tube, the end of which is placed near the bottom of the carboy. A hose and dropper, either with a regulator or with a pinch cock, make it possible to vary the constant head of discharge (Fig. 24). This head H is the distance of the bottom of the aeration tube above the dripper opening.

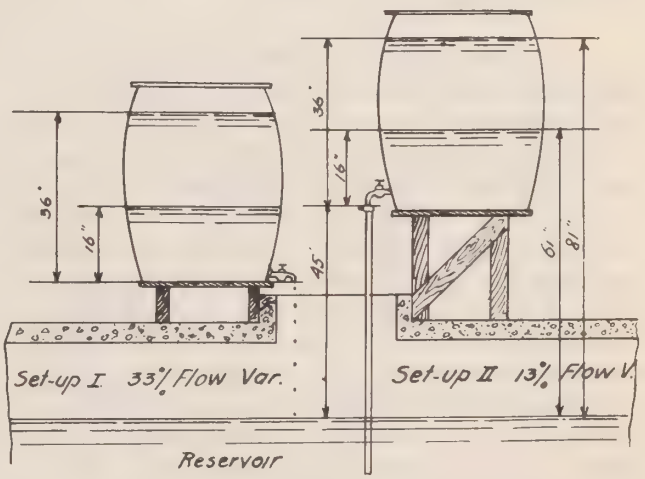

Fig. 23 Simple Barrel Chlorinator

The Wisconsin State Health Department has modified the above by attaching to it a compression air bulb for starting the operation, and a small measuring flask with 1/4" water line connection. This will make it possible to refill the carboy with a clear chlorite solution without opening it. The use of a high percentage sodium fluid hypochlorite seems especially indicated for this instrument. (Fig. 25)

b) A 5 gallon carboy filled with solution is inverted over a small crock or a 2 gallon barrel. In the first instance the liquid is withdrawn from the crock by a thin siphon tube, as in the method described above under "a"; in the second instance the barrel is provided with a faucet. When liquid is withdrawn and the level dips under the opening edge of the carboy, solution will flow out in the barrel, (thereby raising the solution level) and air will pass in until the carboy opening is again just submerged. In this way the discharge head remains practically constant until the carboy is entirely empty. (Fig. 26 and 27)

c. The solution is drawn from a barrel or crock by means of a float provided with a small glass tube in such a way that the opening of the tube is a few, say 2 inches, below the liquid surface. The glass tube is coupled to a wider rubber tube which passes through the barrel wall near the bottom and is there provided with a regulating faucet. If the hose be wide enough to be filled with air, the head of discharge is always the same - 2 inches of water plus length of narrow tube in all cases. If there be no certainty that the rubber tube will not be filled with solution, a wye tube should be used as orifice, the wye being connected with a tube rising above the liquid surface. (Figs. 28 and 29)

d. The solution is made up in a barrel placed at higher level than a second one which receives the settled effluent of the higher one by means of a float valve which maintains the liquid in the second barrel at a constant level. The effluent from this barrel will thus be under a constant head. This second barrel may be (and usually is) replaced by a so-called constant head box, a

small box equipped with a float valve, effuent pipe, and regulation cock. The head in this box is thus kept constant. As this head is smaller than in the barrel, this second method makes the regulation of the smaller flows of solution easier. A good example of this type is shown in a booklet of the New York State Health Department (Fig. 30) in which two barrels are used which are interconnected. One is usually in operation while the solution in the other one is settling. The grit can be removed from the barrels by means of pipes placed in the bottom which drain into a trough. The barrels feed a constant level box, whereas a water seal box may or may not be used depending on whether the point of application is a pump suction pipe or in a channel or basin.

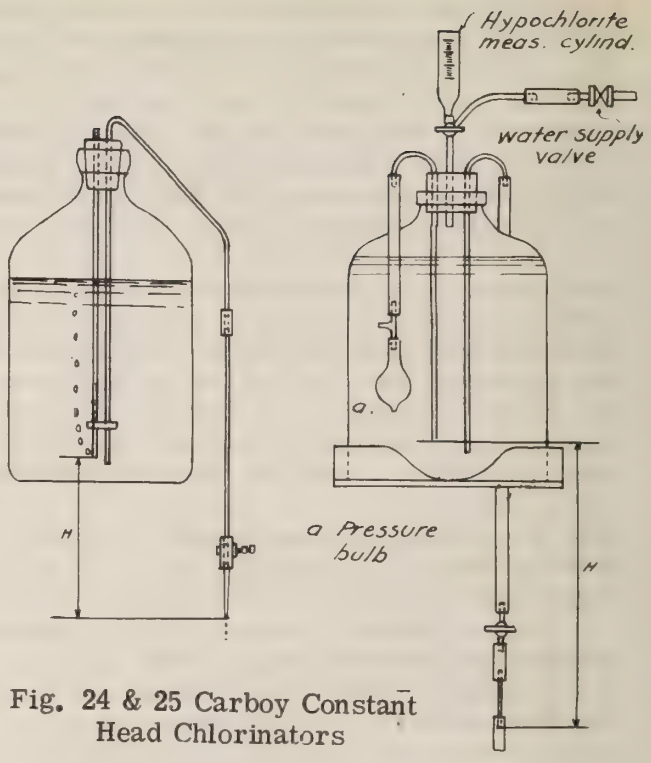

Fig. 24 & 25 Carboy Constant Head Chlorinators

3. The final regulation of the equipment described above is usually empirical for the desired dosage, and accidental changes in the cock setting may result in upsetting this regulation unless the solution be fed drop by drop and the number of drops fed per minute actually counted. This is rather difficult with the use of some of the cocks, and would moreover make the use of receiving funnels necessary. These difficulties are removed in apparatus (Fig. 31) in which the dropper consists of a short length of 1/4" glass pipe introduced through a rubber stopper placed in the top of a burette. The tip of this burette is shortened a little in order to enlarge the opening sufficiently for the needed flow, and then connected to a 1/4" pressure hose by means of a clamp, which hose in turn is connected to the suction end of the service pump by means of a corporation cock. The stopcock of the burette is used to set the dripper on the number of drops needed per minute from the 1% solution in the crocks. The apparatus is calibrated to the pumpage of the service pump and the operator instructed accordingly. Two 10 gallon crocks, coupled by a siphon, are used to carry the solution from which the grit has been filtered out by means of pieces of cotton tied over glass funnels suspended in the solution at the end of the connecting hose. The siphon action is protected by means of a water seal.

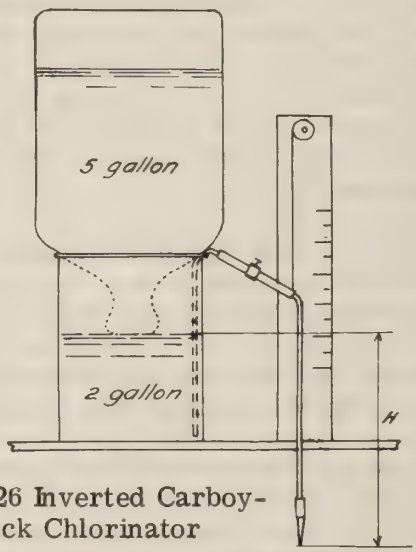

Fig. 26 Inverted Carboy-Crock Chlorinator

An ammonia solution (one quart of liquid ammonia to 2 gallons of water) is kept in a small oak barrel and fed drop wise by a burette to the suction end of the pump two feet ahead of the chlorine. The ammonia calibration is such that one quart only is needed daily and enough ammonia is fed to bind the chlorine.

4. In Hoover's book on water treatment there is an ingenious chlorinator apparatus in which the regulation of the constant head is obtained by a float operating a lever arm which pinches or releases the tube through which the hypochlorite solution flows from a barrel to a jar dispenser (Fig. 32). This jar dispenser is a 1 gallon bottle with bottom removed, provided with a perforated rubber stopper through which a small glass tube runs which is attached to a thin rubber hose which has another curved glass tube outlet at the other end. The bottle is inverted

and held by a stand, and filled with a certain amount of chlorine solution. A laboratory flask, provided with a wooden stopper which in turn is attached to a woodstrip, is placed in the liquid. The woodstrip has a hinge at the other end which is attached to a block nailed to the leg and underside of a table support. To the strip likewise attached is half of a block sawed diagonally in two, and a thin rubber tube which ends in the bottle on one end and is attached to an opening in the barrel near the bottom at the other end. Another block is nailed to the edge of the table in such a way that when the liquid has risen in the bottle to the top level the strip is in a horizontal position and the rubber hose is pinched tight between the two wood blocks, not allowing any solution to pass. Some fluid will then drain out of the bottle and the float will go down slightly; this will release some liquid from the barrel which again will lift float and strip to closing position etc. It is evident that the operation of this device depends entirely on the good condition of the rubber hose, with failure if it cracks or hardens. Dosage can be regulated by the head on the end of the bent glass tip which can be varied.

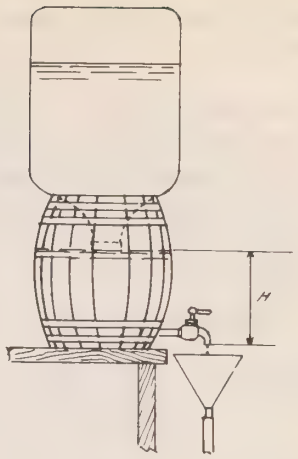

Fig. 27 Inverted Carboy-Cask Chlorinator

The State Health Department of Alabama used a chlorinating device in which the level of the chlorine solution in the dispensing vat is automatically maintained by a small jar float placed in this vat. To this float is attached a length of stiff rubber hose which is plugged at the float end, the other end being attached to the solution barrel. About half way (but still over the dispensing vat) there is an incision in the upper half of the tube. If the tube be kept straight (at the top float position) no liquid will flow through the cut in the dispenser. If the tube be bent through a lowered float position, the cut will open, allowing liquid to pass and to fill the dispenser. (Fig. 33)

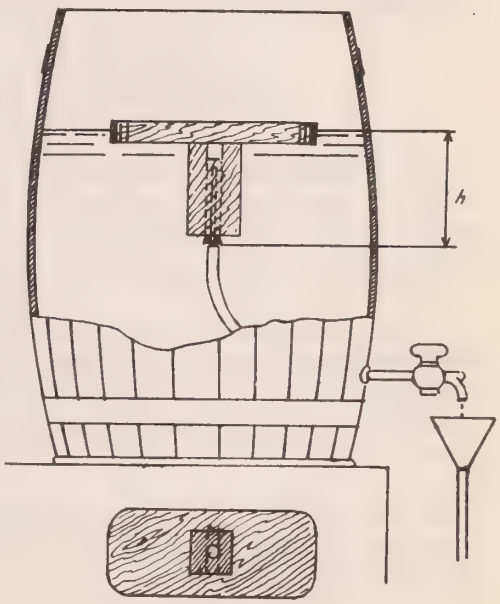

Fig. 28 Float Intake-Barrel Chlorinator with Plan of Float

5. The Texas Health Department recommends the following home-made liquid gas chlorination. In operation, chlorine gas is fed under regulated pressure into a controlled flow of feeding water. The apparatus (Fig. 34) consists of a chlorine gas pressure regulator with reducing valve (a typical needle valve can also be used for this purpose), two quart bottles held in a frame with the top one inverted receiving the gas, and the bottom one nearly filled with water, containing an old type pulsator which serves to measure the dosage; and finally, a home-made injector consisting of a catheter leading the gas deep into a garden hose, with the water flow (from a connected 1/2" T water line) along the catheter dissolving and containing the chlorine gas to the point of application, which, if in an open tank, should be as deeply submerged as possible.

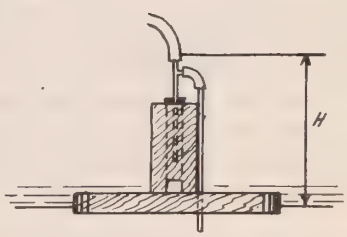

Fig. 29 Float Venting Arrangement to Protect Constant Head

After putting the apparatus together, in which care is taken that there be no kinks in the 1/4" rubber connection hose, the lower bottle is filled with water by opening the water cut-off valve. The chlorine enters the top bottle through an opening in the rubber stopper, leaves it by another opening and enters the pulsator casing tube, driving the water level down in the tube until the gas can escape suddenly through the trap formed by the small pipe in the pulsator. There is a sudden rush of gas which lowers the partial vacuum on top of the water in the bottle and causes the water in the pulsator

casing to rise again, after which the process is repeated.

The dosage rate can be found by reading the number of pulsations per minute, after the chlorine dosage for a certain setting of the water flow has been determined by reading the loss in weight of the chlorine cylinder during a certain time, as follows:

$$\text{pulsation} = \frac{\text{Pounds of chlorine delivered per pounds of chlorine used}}{\text{no. puls./min. (60) (hours run)}}$$

Example: Suppose a pumpage of 240,000 gallons during an 8 hour run with a chlorine dosage of 2 ppm. The time test has shown a dosage of 0.0008 lb. chlorine delivered per pulsation. Rate or pulsation required is:

$$\frac{(240,000\ (2.0)\ (8.34)}{(60)\ (0.0008)\ (8.5)\ (1,000,000)} = 9.8 \text{ (use 10) puls./min.}$$

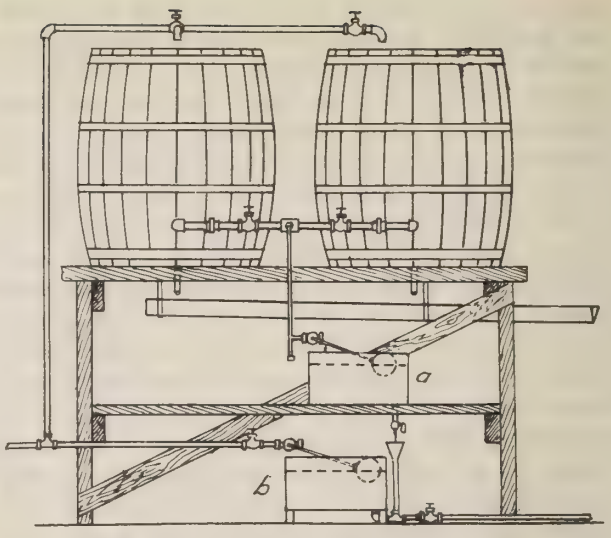

Fig. 30 Dual Barrel Chlorinator with Constant Head Floatbox (a) and Water Seal (b)

The needle valve is adjusted to a small flow and the chlorine valve opened and set at a given number of pulsations per minute, after which the instrument can be calibrated.

This instrument is most satisfactory for service in open lakes or channels or in swimming pools as an emergency measure if little money be available. It is evident that it should be stored in a safe, ventilated place.

A very simple apparatus recommended by the Colorado State Health Dept. for using chlorine gas in contact basins is shown in (Fig. 35).

The State Health Department of Nebraska suggests a very simple and efficient way of sterilization of the well casing of a well pumped by a mechanical pump. A hose is attached at one end to the sampling cock in the discharge line and at the other end to a tee which discharges in 1/2-3/4" slotted pipe 18-24" long with plugged end which has been introduced between well casing and draft pipe by means of the venthole in the pump base. The long end of the tee is connected to a hypochlorinator. The chlorinated water will squirt over the surface of the casing in a spiral way, and will give a much better and faster sterilization than would be obtained by alternately starting and stopping of the pump.

This principal may also be used where no hypochlorinator is available, when the tee is replaced by one of the commercially available injectors (so-called Richards pumps), drawing the chlorine solution from a carboy or crock. As dosage regulation is a

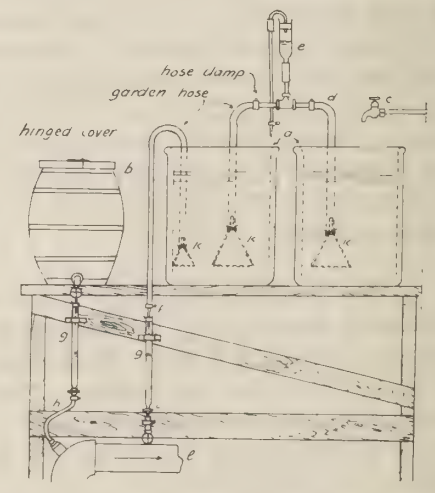

Fig. 31 Emergency Chlorinator and Ammoniator Installation at Delhi, La. Using Burette Drop Dosing Regulation

a. two 10 gal. crocks (1-3⅝ hypochlorite sol.)
b. 5 gal. barrel (1qt. liquid ammonia added to 4 3/4 gal. water). c. city water line.
d. syphon. e. water seal. f. ¼ in. glass pipe. g. 50 cc burettes. h. ¼ in. weld hose. i. cock and valve. k. glass funnel with cotton screens.

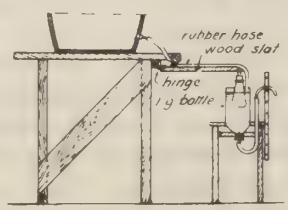

Fig. 32 Pinches Hose Automatic Feeder

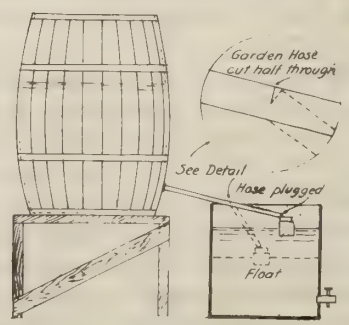

Fig. 33 Cut-Hose Automatic Feeder

minor consideration in this case, the apparatus can be made as simple as possible and no regulating valves are needed. (Fig. 36)

Chlorine Dosage Computation. Some aids for the computation of chlorine dosage are:

a) 10 oz. of 70% or 14 oz. of 50% hypochlorite in 5 gals. water = 1% or 10,000 p.p.m.

b) Total amount of hypochlorite needed to chlorinate a certain number of cubic feet (Qc) of water up to a certain dosage (d) (in p.p.m.) using a chemical of a certain percent (P) available chlorine can be calculated by the formula: $\frac{(Qc)\ (d)}{10\ P}$. The answer will be in ounces.

The above formula may also be used in chlorinating a certain number of gallons (Qg) of water with a slight modification: $\frac{(Qg)\ (d)}{75\ P}$. The answer will also be ounces.

The factor 10 in the denominator of the first formula is multiplied by 7.5, which is approximately the number of gallons in a cubic foot, giving a factor 75 in the denominator of the second formula.

The results given by the above method comes within about 1% of the exact calculation.

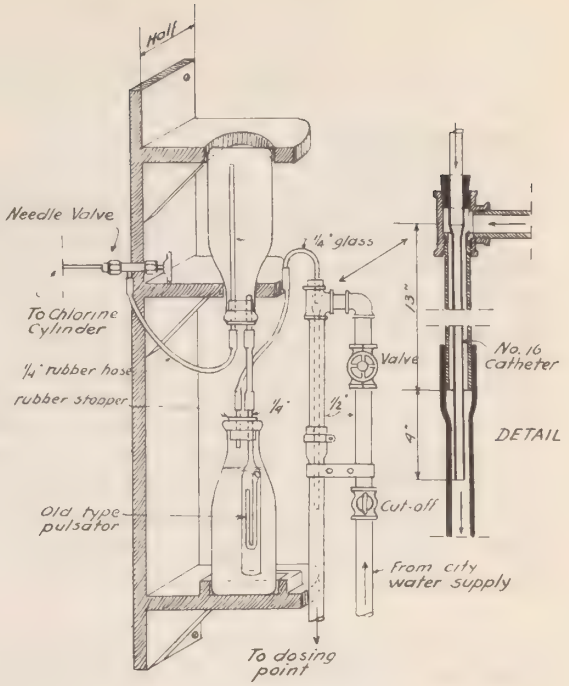

Fig. 34 Low Cost Chlorinator

Example: How much hypochlorite, having 70% available chlorine, should be used to chlorinate a reservoir of 150,000 gallons of water to obtain 2 p.p.m. residual?:

$$\frac{150,000 \times 2}{75 \times 70} = 57 \text{ oz. or about } 3\ 1/2 \text{ lbs.}$$

If 10 oz. of 70% hypochlorite in 5 gals. water gives a 1% solution, then 57 oz., would give 28.5 gals. of 1% strength calcium hypochlorite solution:

$$\frac{57}{10} \times 5 = 28.5$$

A 16% solution would be calculated by dividing 28.5 by 16.

c) For a flow of 100 gals. per minute, a feed about 60 drops per minute of 1% hypochlorite solution is needed to give a dosage of 0.1 p.p.m. (16 drops is equal to 1 cc.). Sometimes an apparatus cannot be satisfactorily regulated to drip. In such a case a small stream of a weaker solution could be used. (About 236 drops per minute, which would be actually a small stream, is equal to 1/2 fluid ounce.)

Example: The service pump of a small water supply pumps 130 gals. per minute. The desired chlorine dosage is 0.3 p.p.m. A 2% hypochlorite solution is used. The setting of the drip feed should then be:

$$\frac{1}{2} \times \frac{130}{100} \times \frac{0.3}{0.1} \times 60 = 118 \text{ drops per minute or } 7\ 1/2 \text{ cc. or } 1/4 \text{ fluid oz.}$$

Explanation of the above factors is as follows:

$\frac{1}{2}$ = $\frac{1\%\text{ hypochlorite solution at 60 drops/min. for 100 g.p.m. flow to produce 0.1 p.p.m.}}{2\%\text{ hypochlorite solution to be used in the problem}}$

$\frac{130}{100}$ = $\frac{130\text{ g.p.m. supply by the service pump}}{100\text{ g.p.m. flow which needs 60 drops/min. of 1\% hypochlorite solution to produce 0.1 p.p.m.}}$

$$\frac{0.3}{0.1} = \frac{0.3 \text{ p.p.m. dosage desired in the problem}}{0.1 \text{ p.p.m. produced by 60 drops/min. of 1\% hypochlorite for 100 g.p.m. flow}}$$

60 = 60 drops/min. of 1% hypochlorite for 100 g.p.m. flow to produce 0.1 p.p.m.

Water Sampling

Method of Freeing Water Samples of Chlorine and Chloramines

All samples of water containing chlorine should be collected in bottles containing sodium thiosulphate. The purpose of using water sample bottles containing sodium thiosulphate is to reduce the chlorine present in a treated water supply at the moment the same is collected. This prevents a continuance of the killing action of the chlorine on the bacteria while the sample is being transported to the laboratory. The bacteriological examination then shows the true sanitary quality of the water at the time the sample was collected. One half ml. of sodium thiosulfate solution (1.5 grams dissolved in 100 ml. of distilled water) is placed in each clean bottle. This amount has been found sufficient to completely reduce residual chlorine in an amount up to 2 p.p.m. in a sample or 130 ml. of water.

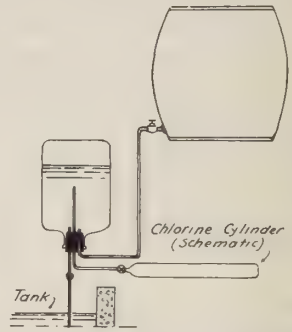

Fig. 35 Carboy Gas Chlorinator

Instead of using sodium thiosulfate solution, approximately 0.02 - 0.05 grams of the powdered form may be added to each clean wet bottle. This amount need not be weighed. An estimated amount on the tip of a spatula is sufficiently accurate.

Number of Samples to be Collected.

The bacteriological examination of water should be of samples collected at representative points throughout the distribution system.

The frequency of sampling and the location of sampling points on the distribution system should be such as to determine properly the bacteriological quality of the water supply.

The minimum number of samples to be collected from the distribution system and examined each month is given below, as recommended by the U.S.P.H.S.:

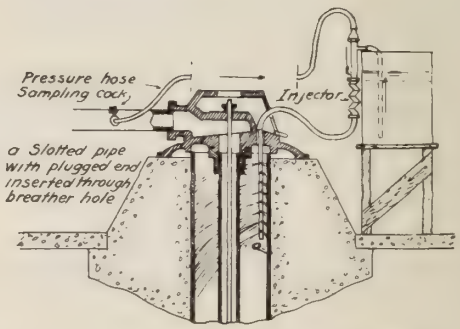

Fig. 36 Chlorination of Wells

Table 14

Population served	Minimum number of samples per month
2,500 and under	1
10,000	7
25,000	25
100,000	100
1,000,000	300
2,000,000	390
5,000,000	500

Collection of Samples for Analysis.

Material:

For bacteriological analysis: Sterile, glass-stoppered bottles, 4-8 oz. capacity with tinfoil cover; metal container for shipping sample; torch for flaming tap.

For chemical analysis: Container with capacity of at least 2, and preferably 4 liters; shipping box.

Technique and Precaution for Collection

1. Bacteriological Samples. Faucet must be flamed with an alcohol lamp or paper torch before obtaining sample. When it is not possible to flame the tap, the water should be allowed to run for 5 minutes before sampling, otherwise just let the standing pipe water run off. To use

the bottle, the tinfoil is loosened from the edges but not removed from the stopper, care being taken to keep it intact. When it is loosened properly it will form an umbrella-like protection for the stopper. When the stopper is removed it should be kept in the same position as in the bottle, head up, and held in one hand while the bottle is held in the other hand and quickly filled up to the beginning of the neck of the bottle with the water to be examined. The stopper should then be replaced firmly and tinfoil rearranged as originally found. The tinfoil is used as an extra precaution against contamination. Sample from reservoir, pond, or stream is taken by submerging a wide-mouth bottle with a sweeping forward motion against the current, so that no water that has touched the hand will enter the bottle, the stopper having been previously removed as directed. When necessary, the wide-mouth bottle should be suspended from a wire and lowered into the water after flaming of both bottle and wire. In collecting from a well, the pump should be worked to get rid of standing pipe water before taking sample. Rope and bucket wells are unsafe in construction and, as a rule, samples should not be collected from them. However, if a special occasion arises such as a suspicion that the well water might be the source of nitrates causing infant cyanosis, then a sample should be taken and the bucket should be filled and contents discarded two or three times before drawing the water for the sample.

Water sample should be labeled. It should show the exact source of water or location in stream, pond or reservoir where sample was taken, date of collection, name of collector. Water survey sheet should be filled out completely.

2. Chemical Samples. The minimum quantity to be collected for ordinary chemical and physical analysis should be not less than 2 liters -- usually 1 gallon is adequate. Care should be taken to obtain a truly representative sample of the water supply.

Care of Specimen Prior to Shipment

1. Bacteriological Samples. If the intervening time between collection and reaching laboratory be not more than a few hours, icing may not be necessary. If more than a few hours be required the temperature should be kept between 43° - 50°F. The interval between collection and examination of samples should not be more than 24 hours. When water samples containing residual chlorine are to be stored or shipped for examination, it is important to obtain sample bottles containing sodium thiosulfate in order to inactivate the chlorine.

2. Chemical Samples. The interval of time allowed to elapse between collection and analysis of samples may be approximately 72 hours for unpolluted waters, 48 hours for fairly pure waters, and 12 hours for polluted waters. If the samples be sterilized by the addition of an acid or germicide, the interval between collection and analysis may be longer. The addition of any such material should be reported to the laboratory. Icing of sample is not necessary.

Preparation for Shipment

Bottles should be placed in ice containers and shipped to laboratory immediately. The shipment should be timed so as to obviate delays in transit and avoid delivery at laboratory on Saturday. The large metal container bottle must be shipped by express, and the single bottle mailing container may be shipped by parcel post.

Special Precautions.

1. When stopper is removed from sample bottle, care must be taken not to touch the bottom of stopper or neck of bottle.

2. Examination should be made as soon as possible even when samples are stored at 50°F. (10°C.)

3. Any deviation from procedures and precautions should be noted on the sample form.

Physical and Chemical Tests for Water Supplies

The following physical and chemical tests for water supplies are described in order to give the sanitarian a dynamic understanding of the significance of the data in a laboratory report. Some of the simpler tests such as the Orthotolidin test, turbidity and color tests may be required of the sanitarian under certain circumstances. Whatever the case may be, a speaking knowledge of these tests is the mark of higher quality in a sanitarian.

Physical Tests

1) Turbidity Test. For turbidities under 100 p.p.m., compare with prepared standard suspensions in bottles, using fullers' earth as suspended matter. The suspensions are rated by means of the candle turbidimeter.

For turbidities between 100 and 1000 p.p.m., the candle turbidimeter is used, which consists of a graduated glass tube and a support so constructed as to hold the glass tube over a "standard candle". The water to be tested is poured into the glass tube until the image of the candle flame just disappears from view. The turbidity of the water will be indicated by the scale reading corresponding to the elevation of the water in the tube.

For turbidities over 1000 p.p.m., the sample is diluted with turbidity-free water until the resultant turbidity is less than 1000, then tested as above and a corrected reading computed. Of widespread use also is the Helligo Turbidimeter, in which the water is placed in a cylinder of a certain depth which rests on a mirror with a circular opening in the center and enclosed in a metal housing. The cylinder is subjected to a light source which can be varied in intensity by turning a knob, and observed through an eye piece on the top of the instrument. The knob, which is provided with an indicator moving over a graduated dial, is turned around until the circular opening in the mirror, which at first appears as a black hole, blends with the surrounding annular ring of the mirror. The number indicated on the dial, by means of a graph provided with the instrument, then gives the turbidity in p.p.m. For varying turbidity ranges, cylinders of varying height and also a filter slide with colors of various depth are used.

2) Color Test. The "true color" is considered to be the color that is due only to substances in solution after the suspended matter has been removed. This is done by centrifuging. The "apparent color" is considered to be the color due to the substances in solution and suspension.

The color of a sample is observed by filling a Nessler tube to the 50 ml. mark with the water to be examined. The intensity of the color of the water in this tube is then compared with the various color standards. This is done by looking down through the tube at a white surface until a standard is found which has the same color as the sample. When the color of the sample is between that of two standards, the color can be estimated. Waters having a color greater than 70 should be diluted and the result calculated accordingly.

An alternate method for determining color is by the use of standard color discs in a colorimeter or color comparing apparatus.

3) Odor Test. This test depends upon the sensitivity of the sense of smell of the laboratory workers and therefore lacks precision. There is no absolute odor value.

The approximate range of the odor value of the sample: Place 50 ml. of sample in one Erlenmeyer flask, 14 ml. in another and 5 ml. in a third. Sufficient odor free water is added to each flask to bring the volume up 200 ml. A fourth flask is filled with the odor free water up to 200 ml. also. The temperatures of the four flasks of fluid should not vary more than $1^{o}C$. In the cold odor method, the samples should have a temperature of 24^{o} - $25^{o}C$.; in the hot odor method, temperatures of 50^{o} to $65^{o}C$. are suitable. The odor free water must really be odor-free; the glassware should be odorless; the room should be odor free; the total time of the test should not exceed one hour lest the sense of smell become fatigued. Shake flask three or four times before smelling. Precision of observation is increased if the odor-free water be smelled alternately with each dilution. The results are recorded as plus or zero for each dilution and reported in "threshold odor" numbers. According to the results obtained, intermediate dilutions should be prepared, in each case using odor-free water to make a total volume of 200 c.c. The threshold odor number is calculated from the amount of sample in the most diluted portion which gives perceptible odor. For example: if 5 ml. diluted to 200 ml. be the most dilute portion giving perceptible odor, than $200 \div 5 = 40$ which is the threshold odor number.

The threshold odor number should not be confused with the "threshold odor concentration." The latter is the smallest amount of odor producing material in ppm. required to give a perceptible odor. If the threshold odor concentration be known, that value multiplied by the threshold

odor number will give the concentration of odor producing material in the sample.

Chemical Tests. It was previously pointed out that the chemical analysis of water as it relates to plant operation can, to a great extent, be derived when the alkalinity to methyl orange, alkalinity to phenolphthalein, and non-carbonated hardness are determined.

1) Alkalinity to Phenolphthalein.

a. Add four drops (0.1 ml.) of phenolphthalein indicator to a suitable size sample of the water to be tested, 50 to 100 ml. if possible, in a white porcelain casserole or an Erlenmeyer flask over a white surface.

b. Stirring constantly, slowly add small quantities of standard acid solution (0.02 or 1/50 normal sulphuric acid) from a burette until the pink color of the solution just disappears.

c. Calculation:

$$\frac{\text{ml. of } H_2SO_4 \times 1000}{\text{ml. of sample used}} = \text{phenolphthalein alkalinity as p.p.m. Ca } CO_3$$

2) Alkalinity to methyl orange.

a. Add two drops of methyl orange indicator to the solution in which the phenolphthalein alkalinity has been determined, or to a suitable size sample 50 to 100 ml. if possible, in a white porcelain casserole or an Erlemeyer flask over a white surface.

b. Stirring constantly, slowly add small quantities of standard acid solution (0.02 normal sulphuric acid) from a burette until the color changes from yellow to pink.

c. Calculation:

$$\frac{\text{Total ml. of } H_2SO_4}{\text{ml. of sample used}} \times 1000 = \text{Methyl orange alkalinity as p.p.m. Ca } CO_3$$

The total alkalinity (also called the Methyl orange alkalinity) is the addition of the "alkalinity to phenolphthalein" (or P alkalinity) and the "alkalinity to methyl orange" of the liquid in which the P alkalinity has been determined.

3) Total (soap) Hardness.

a. Adjust the alkalinity of the sample, either with standard acid or soda ash, so that it is just pink to phenolphthalein.

b. Place a 50 ml. sample in an 8 ounce stoppered bottle.

c. Add standardized soap solution in small amounts at a time, shaking vigorously after each addition until a strong permanent lather is secured which will stand for five minutes with the bottle laid on its side. To avoid mistaking the false end point for the true one in the presence of magnesium salts, at least 0.5 ml. of soap solution should be added after titration is apparently finished, and additional soap solution added if the lather disappears until the true end point has been reached.

d. Calculation:

Total hardness as p.p.m. Ca CO_3 = (1 ml. of soap solution minus the lather factor in ml.) x mg. Ca CO_3 per ml. soap solution x 1000 ÷ ml. of sample. Usually the lather factor (amount of soap solution needed to produce lather in distilled water) is 0.3 to 0.5 in a soap solution standardized to 1 ml. of soap solution equivalent to 1 mg. Ca CO_3.

4) Non-carbonate Hardness.

A. Indirect. Soap hardness - alkalinity.

B. Direct.

1. Measure 200 ml. of the sample into a 500 ml. Pyrex or similar glass Erlenmeyer flask.

2. Measure 200 ml. of distilled water into another 500 ml. Pyrex or similar glass Erlenmeyer flask.

3. Treat the contents of each flask in the following manner:

a) Boil 15 minutes to expel free carbon dioxide.

b) Add 25 ml. of soda reagent (2 grams of sodium hydroxide and 2.65 grams of anhydrous sodium carbonate dissolved in distilled water to make up 1 liter.)

c) Boil ten minutes, cool and rinse into a 200 ml. graduated flask.

d) Dilute to 200 ml. with boiled distilled water.

e) Filter, rejecting the first 50 ml.

f) Titrate 50 ml. of each filtrate with 0.02 normal H_2SO_4 with methyl orange

indicator as described in test for alkalinity to methyl orange.

Water naturally containing bicarbonate and carbonate in excess of calcium and magnesium requires a larger amount of acid to neutralize the sample after it has been treated than is required to neutralize the volume of soda reagent originally added.

If more than one half of the added soda reagent be neutralized repeat with a small volume of sample diluted to 200 ml. with distilled water; otherwise low values for non-carbonate hardness will be found. The calculation is changed in accordance with the volume of sample taken.

g) Calculation:
Non-carbonate hardness as p. p. m. $CaCO_3$ = (ml. H_2SO_4 used for distilled water minus ml. H_2SO_4 used for sample) x 1000 ÷ ml. of sample.

5. Relationships of Certain Chemical Data

The chemistry involved in the determination of alkalinity to methyl orange indicator, alkalinity to phenolphthalein indicator, and non-carbonate hardness, is extremely interesting because from these three determinations about 8 other chemical characteristics of water can be derived as indicated below from a table in "Water Supply and Treatment" by C. P. Hoover.

The three primary tests are:

	Sample Number							
	1	2	3	4	5	6	7	8
Alkalinity to methyl orange	58	70	70	60	60	60	90	80
Alkalinity to phenolphthalein	20	40	50	30	40	40	0	30
Non-carbonate hardness	30	35	-25	-20	-20	-25	30	20

From the results of the above the following may be reported on the laboratory sheet (in terms of $CaCO_3$):

	1	2	3	4	5	6	7	8
Non-carbonate hardness	30	35	0	0	0	0	30	20
Total hardness	88	105	45	40	40	35	120	80
Carbonate hardness	58	70	45	40	40	35	90	60
Caustic Alkalinity	0	10	30	0	20	20	0	0
Bicarbonates of Ca and Mg	18	0	0	0	0	0	90	0
Normal Carbonates of Ca and Mg	40	60	40	40	40	35	0	60
Normal Carbonates of Sodium (Na_2CO_3)	0	0	0	20	0	5	0	0
Caustic Alkalinity as $Ca(OH)_2$	0	10	5	0	0	0	0	0
Caustic Alkalinity as NaOH	0	0	25	0	20	20	0	0

a) Methyl orange indicator measures the total alkalinity, bicarbonates, normal carbonates and hydroxide or caustic alkalinity.

b) Phenolphthalein indicator measures none of the bicarbonates, all of the hydroxides or caustic alkalinity, and half of the normal carbonates.

c) Total hardness is calculated by adding non-carbonate hardness to the methyl orange alkalinity or subtracting negative non-carbonate hardness from it.

d) Caustic alkalinity is present if two times the alkalinity to phenolphtholein exceeds the alkalinity to methyl orange.

e) If the total hardness of an alkaline water be greater than the alkalinity to methyl orange, the difference between the two is equal to the non-carbonate hardness.

f) In case of acid waters, all hardness is non-carbonate hardness.

g) If the total hardness be less than the alkalinity to methyl orange, the difference between the two is equal to the negative non-carbonate hardness (meaning that free sodium carbonate or sodium hydroxide is present.)

h) If the caustic alkalinity be greater than the negative non-carbonate hardness, the difference between the two is equal to the calcium hydroxide ($Ca(OH)_2$ present.

i) If the caustic alkalinity be less than the negative non-carbonate hardness, all the caustic alkalinity is sodium hydroxide (Na OH), and the difference between the non-carbonate hardness and the caustic alkalinity is equal to the normal carbonate of sodium (Na_2CO_3).

j) If the caustic alkalinity be equal to the negative non-carbonate hardness, calcium and magnesium normal carbonates and sodium hydroxide are present.

k) If the phenolphthalein alkalinity be zero, and methyl orange alkalinity is 40, then there are 40 p. p. m. of bicarbonate, but no hydroxides and no carbonates.

l) If the phenolphthalein alkalinity be less than 1/2 the methyl orange alkalinity, then normal carbonate, expressed in terms of calcium carbonate is equal to twice the phenolphthalein alkalinity; bicarbonate present is equal to the methyl orange alkalinity minus the calcium carbonate; and hydroxides are equal to zero.

m) If the phenolphthalein alkalinity be exactly 1/2 the methyl orange alkalinity, then normal carbonate, expressed in terms of calcium carbonate is equal to twice the phenolphthalein alkalinity; bicarbonates and hydroxides are zero.

n) If the phenolphthalein alkalinity be greater than 1/2 the methyl orange alkalinity, the normal carbonate is equal to twice the difference between the methyl orange alkalinity and the phenolphthalein alkalinity, and the alkalinity due to hydroxides is equal to twice the phenolphthalein alkalinity less the total alkalinity. Bicarbonate is equal to zero.

o) If the phenolphthalein alkalinity equals the methyl orange alkalinity, then only hydroxide is present, that is, if each test shows an alkalinity of 50 p. p. m. then the hydroxide present is 50 p. p. m.

Table 15 Summary of Relations Between Phenolphthalein Alkalinity and Methyl Orange Alkalinity

(P stands for phenolphthalein alkalinity in parts per million)
(T stands for methyl orange alkalinity in parts per million)

Result of Titration	Value of radicle in terms of $CaCO_3$		
	Hydroxide	Carbonate	Bicarbonate
P = 0	0	0	T
P < 1/2 T	0	2 P	T - 2 P
P = 1/2 T	0	2 P	0
P > 1/2 T	2 P - T	2 (T-P)	0
P = T	T	0	0

When P is zero, then hydroxide is zero, carbonate is zero, and bicarbonate is equal to T.
When P is less than 1/2 T, then hydroxide is zero, carbonate is 2 P, and bicarbonate is equal to T-2 P.
When P is equal to 1/2 T, then hydroxide is zero, carbonate is 2 P, and bicarbonate is equal to zero.
When P is greater than 1/2 T, then hydroxide is 2 P-T, carbonate is 2 (T-P), and bicarbonate is equal to zero.
When P is equal to T, then hydroxide is T, carbonate is zero, and bicarbonate is equal to zero.

6. a pH Value.

The test in its simplest form is made by taking a quantity of water to be tested, adding the proper indicator, and comparing the color produced with either a standard color in another sealed tube, or in some cases, glass discs are used.

Table 16. Suggested pH Indicators for use in Water Plants

INDICATORS	pH RANGE	COLOR CHANGE
Methyl red	4. 4 to 6. 0	red to yellow
Brom thymol blue	6. 0 to 7. 6	yellow to blue
Phenol red	6. 8 to 8. 4	yellow to red
Thymol blue	8. 0 to 9. 6	yellow to blue
Phenolphthalein	8. 6 to 10. 2	pink to red

The pH value may also be obtained by the electrometric method. All the above tests for waters are made on both raw and treated waters.

b. pH Test - Color Comparator Kit

The following procedure should be carefully followed when using the hellige pocket comparator Model 605. The procedure using other makes of comparators will essentially be the same.

1. Fill the two test tubes with 10 ml. of the water to be tested and place them in the comparator. The tube in the left-hand opening of the comparator is the optical or color "compensation tube" when there is turbidity or color in original sample.
2. Add 0.5 ml. (about 10 drops) of indicator to the test tube in the right-hand opening.
3. Match the colors by turning the disc until the color of the sample and that of the disc most nearly match. The reading is made directly in pH units.

c. Emergency pH Test - Visual Color Development

A clean test tube that will hold at least 10 ml. of water and a bottle of fresh brom thymol blue indicator solution are needed.

1. Add the contents of a small medicine dropper of indicator to the test tube.
2. Add 10 ml. of test water and compare with the following standards:
   Dark blue = about 7.6 (alkaline); pure light blue = about 7.0 (neutral);
   green = about 6.8 (acid); greenish yellow = about 6.4 (acid);
   yellow = about 6.0 (acid).

7. Free Carbon-Dioxide.

The presence of this gas in water leads to the corrosion of pipes, particularly steam and hot water pipes, and to the solution of any lime salts with which the water may come in contact. The determination of CO_2 is of some value, therefore, in determining the corrosive properties of water and also in ascertaining the type of alkalinity existing in the water. Procedure for test is as follows:

a. Place 100 milliliters of water to be tested in a Nessler tube immediately before the test is made.

b. Add about ten drops of phenolphthalein solution to the water. If the water contains CO_2, no color will be produced when the indicator is added.

c. Add sodium hydroxide solution slowly from burette, mixing thoroughly by rotary movement of tube after each addition. Stop adding sodium hydroxide when a faint pink color persists throughout water in tube. Measure the amount of standard sodium hydroxide solution (N/44 or 1/44 normal solution) used by reading the burette before and after determinations. The number of milliliters used multiplied by ten equals the parts per million of free carbon dioxide. To convert CO_2 in parts per million to terms of calcium carbonate in parts per million multiply by 2.272.

8. a. Orthotolidin Test.

After the ten minute chlorine demand of the water has been satisfied, this test will measure slight excess amounts of chlorine. (The chlorine demand of water is the difference between the amount of chlorine applied and the amount of residual chlorine remaining at the end of the contact period.) The orthotolidin solution is made up by dissolving 1 gram of chemically pure orthotolidin in 1 liter of 1% hydrochloric acid. Add 10 drops of the testing solution to a 1 ounce bottle of the water to be tested. If the water changes to a lemon-yellow color, it indicates a slight excess of chlorine over and above the amount necessary to satisfy organic and bactericidal demands without the formation of tastes and odors by the chlorine. No color indicates insufficient chlorine and if an orange-yellow hue results the water is being overdosed and the amount of chlorine applied may be reduced. To make certain that the chlorine has completed its work, ten minutes should be allowed to elapse after the chlorine has been added to the water before the test is made.

Orthotolidine solutions should not be used after they are six months old, and must be stored in an amber bottle. In chlorinated water containing no more than 0.3 p.p.m. iron, 0.01 p.p.m. manganic manganese, or 0.10 p.p.m. of nitrite nitrogen, the characteristic yellow color with orthotolidine may be accepted as being due to chlorine. The orthotolidine-arsenite test should be employed if excessive amounts of these interfering substances be present or suspected of being present.

Chloramine reacts with orthotolidin in the same way as chlorine. In alkaline waters the orthotolidin test may result in blue color. Doubling the amount of orthotolidin solution used in making the test will bring about the normal yellow color.

Colorimeter apparatus may be used to determine the quantity of active chlorine in solution. The maximum residual which can be measured with a colorimeter is 2 p. p. m. as the color range in higher residuals is too indefinite for colorimetric measurements.

b. Chlorine Residual "Flash" Test - (Range 0.0 to 1.0 p. p. m.)

The following procedure should be carefully followed when using the Hellige pocket comparator, Model 605. The procedure using other makes of comparators will be essentially the same.

1. Fill the two test tubes with 10 ml. of the water to be tested and place them in the comparator. The tube in the left-hand opening of the comparator is the optical or color "compensation tube" when there is turbidity or color in original sample.
2. Add with force 1.0 ml. (about 20 drops) or orthotolidine to the test tube in the right-hand opening.
3. Quickly (within 10 seconds) match the colors by turning the disc until the color of the sample and that of the disc most nearly match. The reading is made directly in parts per million.

c. Orthotolidine-Arsenite Chlorine Residual Test

The equipment used is the same as noted above for the "Flash" test with the addition of sodium arsenite solution (5 gm. of sodium arsenite in 1 liter of distilled water).

1. Add 0.5 ml. of sodium arsenite solution to 10 ml. of test water in a test tube, mix and then add 0.5 ml. of orthotolidine.
2. Compare with color standards against a "compensation tube" as above, and record result as false residual.
3. Place 0.5 ml. of orthotolidine in a test tube and then add 10 ml. of test water.
4. Immediately add 0.5 ml. of sodium arsenite solution.
5. Compare with color standards against a "compensation tube" and record results as free chlorine plus false residual.
6. The difference between readings found in steps (2) and (5) will yield the free chlorine residual.

d. Field Test for Chlorine Residual - Drop Dilution Method -(Range over 10p.p.m.)

1. Place 0.5 ml. of orthotolidine into the test tube.
2. Add 10 ml. of distilled water and mix thoroughly.
3. Add one drop of test water to the tube and make a color comparison reading as before.
4. If the addition of one drop of water produces no color, discard the contents of the tube and proceed as before but add two drops of the water under test. Continue this procedure until an easily readable color is produced (not less than 0.1 p. p. m.).
5. Calculations of results are made by using the following formula:

$$\text{PPM Residual Chlorine} = \frac{\text{Volume of cell in ml.}}{\text{ml. of sample}} \times \text{Comparator reading}$$

Example -

$$\text{20 p. p. m. residual} = \frac{\text{10 ml.}}{\text{0.05 (1 drop)}} \times \text{0.10 p. p. m.}$$

e. Emergency Test for Combined Chlorine Residual in Drinking Water (1.0 p. p.m.)

1. Put 1/2 inch of chlorinated water into a cup and add 15 to 20 drops of orthotolidine.
2. Let the solution stand for 5 minutes out of the sunlight and then note color.

Interpretation: No color = No chlorine; Canary yellow = Not enough chlorine; Deep yellow = Satisfactory; Orange red = More chlorine than necessary but it may still be usable in emergencies; Bluish green = Alkaline or hard water. Adding twice as much orthotolidine may provide the desired color development.

Sanitary Standards Relating to the Manufacture, Processing, Storage, and Transportation of Ice

The following standards were drafted by the U.S. Public Health Service and recommended in 1964. The section on definitions was left out since these terms are self-evident to public health workers.

Ice Quality

Ice intended for use for human consumption or to be used in direct contact with food, food equipment, or food utensils, shall meet the bacteriological and chemical standards of quality of applicable State and local laws, ordinances, and regulations, or in the absence thereof, the Public Health Service Drinking Water Standards, 1962 (Publication No. 956).

Water Supply and Treatment

1. All water used in ice plants, including that used in preparing brine solutions, shall be of a safe, sanitary quality and from an approved public or private water supply system which is constructed, protected, operated and maintained in conformance with applicable State and local laws, ordinances, and regulations, or in the absence thereof, the Public Health Service Drinking Water Standards, 1962 (publication No. 956).
2. Only potable water shall be used in dipping wells or sprays for the removal of ice cakes from the ice cans or tanks. Ice shall not come into direct contact with water in dipping wells.
3. If water be treated at the ice plant, the treatment and facilities shall be approved. Use of chemicals or additives shall be in accordance with regulations promulgated under the Food Additives Amendment to the Federal Food, Drug, and Cosmetic Act.
4. All water filters, settling tanks, and other treatment facilities, shall be cleaned as often as necessary to keep them operational and in a clean and sanitary condition. Adequate and suitable tests shall be made and records shall be maintained when such facilities are used.
5. If approved, a non-potable water supply may be permitted within the establishment for purposes of fire protection and the cooling of refrigeration equipment.

Sewage Disposal

All sewage and waste water shall be disposed of by means of a public sewerage system or an approved sewage disposal system which is constructed, operated and maintained in conformance with applicable State and local laws, ordinances, and regulations.

Plumbing

1. All plumbing shall be sized, installed and maintained in accordance with applicable State and local plumbing laws, ordinances, and regulations, or in the absence thereof, the National Plumbing Code, American Standards Association A40.8-1955.
2. The potable water supply piping shall not be connected with any non-potable water supply system whereby the non-potable water can be drawn or discharged into the potable water supply system. The piping of any non-potable water system shall be adequately and durably identified, such as by distinctive yellow-colored paint, so that it is readily distinguished from piping which carries potable water; and non-potable water piping shall not be connected to equipment, except when approved for purposes of fire protection and the cooling of refrigeration equipment. Fire protection outlets shall be so designed or protected as to discourage usage for any other purpose.
3. The potable water system shall be installed in such a manner as to preclude the possibility of backflow into the system.
4. Drain lines from equipment shall not discharge waste water in such a manner as to permit the flooding of floors or the flowing of water across working or walking areas, or in difficult to clean areas, or otherwise create a nuisance.
5. Soil, waste or drain pipes shall be so located, installed and maintained as not to constitute a source of contamination for ice, equipment, or utensils, or create an insanitary condition or nuisance.

Air for Agitation

1. Air used for water agitation shall be filtered or otherwise treated to render it free of dust, dirt, insects, and extraneous material. Air intakes shall be located and maintained in an approved manner. Filters shall be located upstream from the compressor and shall be easily removable for cleaning or replacement.

2. The blower or compressor for supplying air for water agitation shall be designed so it will deliver oil-free air. Oil-free air may be produced by one of the following methods or its equivalent:

a. Use of carbon ring piston compressor.
b. Use of an oil-lubricated compressor with effective provision for removal of any oil vapor.
c. High-pressure water-lubricated or nonlubricated blowers.

Sanitary Facilities and Operation

1. Ice manufacturing, processing, packaging, and storage operations shall be conducted in a building or structure that is enclosed and maintained in a sanitary condition. Such building or structure shall protect the ice, equipment, and utensils from dust, dirt, rodents, insects, and other contaminating sources. Ice for human consumption shall not be processed or packaged on open platforms or on trucks or other vehicles used for delivery.

2. The floors, walls and ceilings of all rooms in which ice is manufactured, processed, packaged, and stored shall be of such material, and so constructed as to be maintained in a clean, sanitary condition. They shall be kept clean and in good repair. Unless otherwise approved by the health authority, such rooms shall be used for no purpose or operation other than those normally associated with the manufacture, processing, packaging, and storage of ice and the production of refrigeration.

3. Ice-contact surfaces, including loading platforms, conveyors, and chutes, shall be easily cleanable and shall be kept clean and in good repair. Loading platforms, conveyors, chutes, and other contact surfaces which are not maintained at or below freezing shall be washed as often as necessary to keep them clean.

4. At least 10 foot-candles of light shall be required on surfaces in all rooms or areas in which ice is manufactured, processed, or packaged. At least 10 foot-candles of light shall also be required in utensil washing areas, toilet rooms, and handwashing areas. Storage rooms shall have at least 5 foot-candles of light as measured 30 inches from the floor. Sources of artificial light shall be provided and used to the extent necessary to provide the required amount of light on those surfaces and in those areas when in use and when being cleaned.

5. All equipment and utensils used in ice plants shall be of easily cleanable construction and shall be kept clean, in good repair, and shall be handled and stored in a sanitary manner. Materials used as ice-contact surfaces shall, under use conditions, be smooth, nontoxic, and relatively nonabsorbent. Ice tanks and cans shall be kept in a leakproof condition and the inner surface of such containers shall be free of corrosion.

6. Canvas containers shall not be used unless provided with a sanitary single-service liner so as to completely protect the ice.

7. Single-service articles shall be stored, dispensed, and handled in a sanitary manner, and shall be used only once.

8. Freezing tank covers shall be so designed and of such material as to protect the ice containers from splash, drip and other contamination; shall be easily cleanable;[1] and shall be kept clean and in good repair. Such covers shall be equipped with rings or similar devices, thereby minimizing splintering of covers when hooks are used for pulling. Can or tank covers and the ledges and sides of the tank upon which the cover rests, shall be cleaned as often as necessary to keep them in a sanitary condition and in a manner satisfactory to the health authority.

9. All portable can or tank fillers, core suckers, needles, core fillers, drop tubes, pipes, tongs, picks, and covers shall be maintained in a clean sanitary condition. When not in use, they shall be stored in clean cabinets, or other suitable enclosures which protect them from contamination. If such equipment or utensils contact the floor or are otherwise subjected to contamination, they shall be thoroughly cleaned before reuse.

10. No person shall enter the tank room or any room or area where ice contacts a walking surface, unless he wears clean suitable boots or shoe coverings. Such boots or shoe coverings shall be removed when the person leaves such room or area; provided, that if boots or shoe coverings not be removed, they shall be thoroughly washed in an approved solution before reentering such rooms or areas. Street shoes without suitable coverings shall not be used in these areas.

1. If paint be applied to covers to make them easily cleanable and prolong their life, it shall be applied to dry covers and so bonded as to resist peeling, chipping, and spalling, and shall be nontoxic.

11. Air pipes, and coring or sucking devices shall be used as needed to produce a product free of rust or other foreign materials.

12. All ice blocks shall be thoroughly washed with potable water as they come to the delivering platform prior to distribution.

13. Processing and packaging of ice to be used for human consumption shall be accomplished in a sanitary manner with equipment and utensils that have been regularly and thoroughly cleaned. Hands shall not come into direct contact with the ice when other methods of handling can be used.

Transportation of Ice

1. Ice, while being transported or delivered, shall be protected from contamination from dust, dirt, or any other source. The ice compartment of vehicles used in transporting or delivering ice shall be of cleanable construction and shall be kept clean and in good repair.

2. Vehicles used for transporting or delivering unpackaged ice shall be of closed construction with tight-fitting covered bodies, or if of open construction, shall have tight floors and sides and shall be equipped with clean tarpaulins covering the entire load and reaching all the way to the floor in back of the load. If tarpaulins be used, they shall be thoroughly cleaned after each usage.

3. All vehicles hauling unpackaged ice shall be thoroughly washed immediately prior to loading with ice.

Toilet Facilities

1. Toilet facilities shall be adequate and conveniently located, and shall be accessible to the employees at all times.

2. Toilet rooms shall be completely enclosed, and shall have tight-fitting, self-closing doors. Such doors shall not be left open except during cleaning or maintenance. If vestibules be provided, they shall be kept in a clean condition and in good repair.

3. Toilet facilities, including the toilet room and fixtures, shall be kept clean and in good repair, free from flies and objectionable odors, and shall be vented to the outside air.

4. A supply of toilet tissue shall be provided at each toilet at all times.

5. Easily cleanable receptacles shall be provided for waste materials.

Hand-Washing Facilities

1. Lavatories shall be located within or immediately adjacent to all toilet rooms.

2. Lavatories shall be adequate in size and number and shall be so located as to permit convenient and expeditious use by all employees.

3. Each lavatory shall be provided with hot and cold or tempered running water. Where hot and cold running water is provided, a mixing valve or combination faucet is recommended. Steam mixing valves are prohibited.

4. An adequate supply of hand-cleaning soap or detergent shall be available at each lavatory. An adequate supply of sanitary towels, or an approved hand-drying device, shall be available and conveniently located near the lavatory. Common towels are prohibited. Where disposable towels are used, waste receptacles shall be located conveniently near the hand-washing facilities.

5. Lavatories, soap dispensers, hand-drying devices, and all other components of the hand-washing facilities shall be kept clean and in good repair.

Housekeeping

1. All parts of the establishment and its premises shall be kept neat, clean, and free of litter and debris.

2. Effective control measures shall be utilized to eliminate rodents, flies or other vermin from the premises.

3. Insecticides and rodenticides shall not be used in any way as to contaminate ice or ice contact surfaces, nor to constitute other hazards to employees or customers.

Personnel

1. No person while affected with any disease in a communicable form, or while a carrier of such disease shall work in any area of an ice plant in any capacity in which there is a likelihood of such person contaminating water, ice, or ice contact surfaces with pathogenic organisms, or transmitting disease to other individuals.

2. All employees shall wear clean outer garments, maintain a high degree of personal cleanliness, and conform to good hygienic practices while on duty. They shall wash their hands thoroughly with soap and warm water in an approved hand-washing facility before starting work and as often as may be necessary to remove soil and contamination. No employee shall resume work after visiting the toilet room without first washing his hands.

3. Employees shall not use tobacco in any form in any room used for the manufacture, processing, packaging or storage of ice.

4. Unauthorized persons shall not be permitted in any room where ice is manufactured, processed, packaged or stored.

Regulations for Bottled Drinking Water and Other Bottled Beverages

Definitions:

Bottled Water means any artificial or natural mineral, spring, or other water bottled for drinking purposes.

Bottled Beverage means any liquid other than potable drinking water that is prepared and bottled for drinking purposes.

Water or Beverage Bottling Plant means any place or establishment in which bottled waters or beverages are prepared for sale. No one should be allowed to operate a commercial water or beverage bottling plant without an unrevoked permit from the board of health.

Water and beverage bottling plant buildings should conform to the same requirements and standards as food manufacturing establishments. The water bottled and the water used in beverages or otherwise in the plant should conform to the Public Health Service Drinking Water Standards. The bottle labels should state the name and address of the bottling company and permit number, the approved chemical analysis of the water, and all substances added and all treatment processes applied. Claims of medicinal and health-giving properties

must not be allowed.

Any operator of water or beverage bottling plants must submit to the board of health, on request, records covering the source, processing, transportation and distribution of bottled beverages or water. A monthly record should be submitted containing at least a statement of the average number of establishments served during the month, volume of water or beverage delivered during month, analysis of water and data on materials in beverages and any changes in source of water or other materials used.

Location and Use of Building: The building, or portion thereof, employed for the manufacture of bottled water and other beverages, shall be used for no other purpose, and shall be so located as to be protected from objectionable surroundings.

Floors: The floors of all rooms shall be of concrete, tile, or other impervious material with a smooth surface, and shall be maintained in a clean and sanitary condition. They shall be graded and sloped to properly trapped drains.

Walls and Ceilings: Walls and ceilings in the syrup and bottling rooms shall be of hard, sound materials with smooth, easily cleaned surfaces, frequently painted and maintained clean.

Light and Ventilation. All rooms shall be adequately lighted and ventilated.

Protection Against Flies: All openings to the outer air shall be screened or otherwise protected, where necessary, against entrance of flies. The syrup room shall be especially protected against flies.

Syrup Room: The syrup room shall be separately enclosed, well ventilated and lighted; provided with sinks and hot and cold water; thoroughly protected against vermin, flies, dirt, and dust; and so constructed as to be easily cleaned.

Water and Sewer Connections: Running water of satisfactory quality shall be easily accessible to all parts of the plant. Adequate provision shall be made for prompt removal and proper disposal of waste water and sewage.

Toilets and Washrooms: Adequate toilet and lavatory facilities shall be provided and shall be maintained in a clean and sanitary condition. Toilet and washroom fixtures shall be so constructed and so operated as to prevent return-flow, or back-siphonage, from such fixtures into the water supply.

Washing, Carbonating, Filling and Crowning Machinery: Every plant manufacturing bottled beverages or bottling drinking water shall be equipped with suitable mechanical bottle washing apparatus and with approved machines for carbontaing, filling, and crowning, so that these operations can be performed in such a manner as to prevent any part of the operators or his clothing from coming in contact with those surfaces of the bottle which come in contact with the beverage. Bottle washing machines shall be so constructed and operated as to prevent back-siphonage, or return-flow, into the water supply lines. Corks must be used only once, screw caps may be reused after proper sterilization. All containers filled with drinking water must, after capping, be covered with a hood of parchment or other acceptable material.

Conveyors and Cases: Conveyors and cases shall be maintained in a clean and sanitary condition.

Syrup Making Equipment: All vats, jars, mixing and storage tanks, pipe lines, filters, and other apparatus employed in the preparation of syrups, shall be of sanitary construction and lined with materials resistant to the action of syrup ingredients.

Water Clarification Equipment: Electrical or chemical coagulation devices and filters employed for clarification of water, shall be of types approved by the board of health,

shall not be operated beyond their rated capacity, and shall be maintained in a clean and sanitary condition at all times.

Miscellaneous Equipment: Every plant manufacturing bottled beverages shall be adequately provided with thermometers, acid and sugar hydrometers, gas volume testers, and apparatus for ascertaining the alkalinity and causticity of the soaker solution employed in bottle washing.

Plant Layout: Where practicable, the operations of bottle washing and filling, compounding and mixing of syrups, and shipping, shall be performed in separate rooms. Where this is not feasible, the various operations shall be located in the available space in such a manner as not to interfere with one another.

Bottle Washing: Hand bottle washing, except as a preliminary to subsequent mechanical washing, is prohibited. All bottles shall be thoroughly cleaned and sterilized, immediately before filling, by means of a suitable automatic mechanical washing machine.

Preparation of Syrups: Syrups shall be prepared in a clean manner, and every precaution shall be taken against contamination or absorption of deleterious substances during the process of preparation and subsequent storage.

Storage: All bottles, cans, corks, and multi-use containers and equipment shall be stored in separate rooms and protected from contamination at all times.

Preparation and Storage of Colors: All non-alcoholic colors shall be prepared in small batches, sterilized immediately before use, and stored so as to be protected against dust.

Storage of Finished Goods: The finished products shall be stored in such a manner as not to interfere with the sanitation of the bottling room.

Refuse and Rubbish: Broken bottles and such other refuse and rubbish as may be found in returned cases, etc., shall be placed in suitable containers and properly disposed of.

Sterilization and Cleaning of Apparatus: All pipe lines, apparatus and containers employed in the manufacturing processes shall be thoroughly washed, cleaned, and sterilized, at frequent intervals, so as to be maintained at all times in a clean and sanitary condition. Steam, hot water, chlorine or other equally efficient agents are permissible for sterilization.

Sugar: The sweetening agents employed in the manufacture of bottled beverages shall consist exclusively of edible sugar such as sucrose, dextrose, invert sugar, and levulose, singly or in combination, or other suitable and nutritious carbohydrates. The use of saccharin or similar non-nutritious materials is prohibited except under provisions established by the board of health.

Preservatives: No antiseptic, disinfectant, or preservative prohibited by food and drug or health laws shall be used in beverages.

Acids and Flavors: Citric, tartaric, or other edible organic acids, and their salts, may be used. Mineral acids, other than phosphoric acid or its salts are prohibited in beverages. Acids and flavors shall be stored in suitable containers, properly labeled, and protected against contamination.

Colors: Only caramel, U. S. certified coal tar, or approved vegetable colors shall be used.

Appearance, Sanitary Habits and Health of Employees: All persons engaged in the mixing of syrups, filing of bottles, or in any other capacity which brings them in contact with the ingredients or containers of beverages, shall be free from communicable diseases or insanitary habits, and shall be of clean, neat appearance and shall wear clean clothes.

Suggested Legislation for Urban Water Supply and Sewerage Systems*
[Title should conform to State requirements]

(Be it enacted, etc.)

Section 1. Short Title. This Act shall be known and may be cited as the "(State) Urban Water Supply and Sewerage Systems Act."

Section 2. Findings and Policy. (a) The (State) legislature finds that properly planned and installed individual and community water supply systems and sewerage systems in and near urban areas --

(1) assure the availability of adequate and safe water for various purposes, including drinking and culinary use;
(2) promote the health and welfare of citizens of this State by preventing the pollution of ground and surface water;
(3) eliminate nuisances and hazards to the public health;
(4) contribute to proper conservation and use of ground water;
(5) encourage economical and orderly development of land for residential, industrial, and other purposes, and are essential to the orderly processes of urban growth.

(b) It is, therefore, declared to be the public policy of this State to eliminate and prevent health and safety hazards and to promote the economical and orderly development and utilization of water and land resources of this State by encouraging planning and provision for adequate individual and community water supply systems and sewerage systems and by providing for the standards and regulations necessary to accomplish these purposes.

Section 3. Definitions. As used in this Act:
(a) "Community plan" means a comprehensive plan and all amendments and revisions thereof for the provision to a municipality or municipalities of both adequate water supply systems and sewerage systems, adopted by a municipality or municipalities having authority to provide or having jurisdiction over the provision of such systems.

(b) "Community sewerage system" means any system, whether publicly or privately owned, serving two or more individual lots, for the collection and disposal of sewage or industrial wastes of a liquid nature, including various devices for the treatment of such sewage or industrial wastes.

(c) "Community water supply system" means a source of water and a distribution system including treatment facilities, whether publicly or privately owned, serving two or more individual lots.

(d) "Department" means the [designated agency presently having authority to regulate sanitary practices within the State, usually the State Department of Health] .

(e) "Individual sewage system" means a single system of sewers and piping, treatment tanks, or other facilities serving only a single lot and disposing of sewage or industrial wastes of a liquid nature, in whole or in part, on or in the soil of the property, into any waters of this State, or by other methods.

(f) "Individual water supply system" means a single system of piping, pumps, tanks or other facilities utilizing a source of ground or surface water to supply only a single lot.

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*Recommended State Legislation and Regulations, Public Health Service, 1965.

(g) "Lot"[1] means a part of a subdivision or a parcel of land used as a building site or intended to be used for building purposes, whether immediate or future, which would not be further subdivided.

(h) "Municipality" means a city, town, borough, county, parish, district, or other public body created by or pursuant to State law, or any combination thereof acting cooperatively or jointly.

(i) "Potable water" means water free from impurities in amounts sufficient to cause disease or harmful physiological effects with the bacteriological and chemical quality conforming to applicable standards of the Department.[2]

(j) "Subdivision"[3] means the division of a single tract or other parcel of land, or a part thereof, into two or more lots, for the purpose, whether immediate or future, of sale or of building development, and shall also include changes in street lines or lot lines, provided, however, that divisions of land for agriculture purposes into parcels of more than _____ acres not involving any new street or easement of access, shall not be included within the meaning of "subdivision".

Section 4. Community Plans. (a) Each municipality designated under Section 5 (e) of this Act shall, after reasonable opportunity for public hearing thereon, submit to the Department a community plan within the time prescribed by the Department pursuant to Section 6 (a) of this Act, and shall from time to time submit amendments or revisions of such plan as it deems necessary or as may be required by the Department.

(b) Within an appropriate area for development of a single plan for water and sewerage systems, the required community plan, any amendment or revision thereof may be submitted jointly by the municipalities concerned.

(c) Every community plan shall delineate, in accordance with applicable regulations adopted by the Department pursuant to Section 5 of this Act, those areas where --

(1) (A) community water supply systems must be provided;
(B) individual water supply systems may be installed and used during an interim period pending the availability of a programmed community water supply system;
(C) individual water supply systems may be installed and used for an indefinite period.
(2) (A) community sewerage systems must be provided;
(B) individual sewerage systems may be installed and used during an interim period pending availability of a programmed community sewerage system;
(C) individual sewerage systems may be installed and used for an indefinite period.

(d) In addition every required community plan shall --
(1) provide for the orderly expansion and extension of community water supply systems and community sewerage systems in a manner consistent with the needs and plans of the area;
(2) provide for adequate sewage treatment facilities which will prevent the discharge of untreated or inadequately treated sewage or other waste of a liquid nature into any waters, or otherwise provide for the safe and sanitary treatment of sewage and other liquid waste;
(3) delineate with all practicable precision those portions of the municipality in which community systems may reasonably be expected to serve within five years, within ten years, and after ten years, and any portions in which the provision of such services is not reasonably foreseeable, taking into consideration all related aspects of planning, zoning, population

1. The definitions should be consistent with any definitions of the same terms established in the State's planning, subdivision control, and zoning enabling acts. There should be included necessary additional provisions to accommodate the definitions to condominium and cooperative developments where there are individual interests in land occupied by multiple dwellings and multiple occupancy developments on a single lot.
2. In the absence of available State standards, PHS Drinking Water Standards (PHS Publication 956) are recommended.
3. See footnote 1.

estimates, engineering, and economics, and any existing State plan affecting the development, use, and protection of water resources;

(4) establish procedures for delineating and acquiring on a time schedule, pursuant to Subsection (d) (3) of this Section, necessary rights-of-way or easements for community systems;

(5) set forth a time schedule and proposed methods of financing the construction and operation of each programmed community system together with the estimated cost thereof;

(6) be submitted for review to official planning agencies having jurisdiction, including a comprehensive planning agency with areawide jurisdiction if one exists, for consistency with programs of planning for the area, and such reviews shall be transmitted to the Department with the proposed plans; and

(7) include provision for periodic amendment or revision of the plan.

Section 5. Administration--Department Powers and Functions.

(a) The Department shall adopt and from time to time amend rules and regulations which provide for --

(1) the control, limitation or prohibition of installing, and use of individual and community water supply systems and sewerage systems in accordance with the provisions of this Act;

(2) the procedures in connection with the preparation, submission, revision, review, and approval or disapproval of community plans;

(3) the minimum contents of such plans;

(4) the criteria upon which approval of such plans shall be based, and

(5) such other matters as may be necessary or appropriate to the administration of this Act.

(b) Such regulations in providing criteria for the delineation in community plans of areas pursuant to Section 4 (c) of this Act, and for the approval of community plans, shall be formulated so as to implement the policies of this Act as stated in Section 2, and shall require consideration of the present and future density of population, size of the lots, contour of the land, porosity and absorbency of the soil, ground water conditions and variations therein from time to time and place to place, including availability of water from unpolluted aquifers or portions thereof, type of construction of water supply systems and sewerage systems, size of the proposed development, and other pertinent factors.

(c) Such regulations shall --

(1) require the installation of community water supply systems and community sewerage systems and the connection of all premises thereto, if such systems be reasonably necessary to protect the public health, giving due consideration to such factors as are set out in Section 5 (b) of this Act. Such systems shall be designed so as to permit connection to a larger system at such time as the larger system becomes available, and

(2) permit, in areas where community water supply systems or community sewerage systems are not available nor required to be installed under Section 5 (c) (1) of this Act, but are programmed to become available within a reasonable period of time not to exceed _____ years,[4] individual water supply systems or individual sewerage systems, or both, provided that: (A) such individual water supply systems or individual sewerage systems be adjudged by the Department to be adequate and safe for use during the period before a community water supply system or a community sewerage system, as the case may be, are scheduled to become available, (B) adequate provisions be made prior to or at the time of the installation of such individual systems to permit the discontinuance of their use and the connection of the premises served thereby to the community water supply system and the community sewerage system, respectively, in as economical and convenient a way as can be foreseen. Such provision for any subdivision shall include either the posting of a bond, with satisfactory surety, to secure to the municipality the actual construction and installation of such systems at a time fixed by the

4. Five years is suggested as a reasonable period of time. The time period should be determined on the basis of experience in the State where this legislation is enacted.

municipality not in excess of _____ years[5] and in accordance with the regulations issued hereunder and with all other State and municipal requirements, or such other arrangements as may be deemed necessary and adequate to accomplish the purposes of this Section, and

(3) permit, in areas where community water supply systems or community sewerage systems are not available nor required to be installed under Section 5 (c) (1) of this Act, nor programmed to become available within a reasonable period of time not in excess of _____ years,[6] individual waste supply systems or individual sewerage systems, or both as the case may be, provided that such individual systems be adjudged by the Department to be adequate and safe.

(d) The Department is authorized to issue such additional regulations as may be necessary to carry out the provisions of this Act.

(e) The Department shall designate municipalities which are required to submit community plans, amendments, and revisions thereof in which applicable regulations shall apply as may be necessary to accomplish the purposes of this Act. The designation shall take into consideration such factors as present and future population trends and densities, patterns of urban growth, geographic features and political boundaries, the location and plans for location of utility systems, the distribution of industrial, commercial, residential, governmental, institutional, and other activities, and the existence of any area for which comprehensive planning is being undertaken.

(f) After public hearing upon not less than sixty (60) days' prior notice published in one or more newspapers as may be necessary to assure general circulation throughout the State,[7] such regulations shall be adopted, amended, or revised.

(g) The Department is hereby authorized to approve or disapprove community plans submitted in accordance with Section 4. The Department may approve a community plan in part provided that the part approved includes all the required elements for such plan and applies to at least ninety percent of that geographic area of the municipality for which a plan is required. When the plan is disapproved, in whole or in part, the Department shall notify the municipality in writing setting forth the reasons for such disapproval. Any such disapprovals and any other actions of the Department under this law are subject to judicial review as to whether they are arbitrary, capricious or unreasonable, and otherwise as provided for under the laws of the State.[8]

(h) The Department, upon request, shall provide technical assistance and consultation to municipalities in preparing and coordinating community plans required in Section 4 of this Act, including revisions of such plans.

(i) The Department may conduct studies, surveys, investigations, research, and analyses to accomplish the purposes of this Act.

(j) [Use this Subsection to establish a program of State aid to municipalities for preparing and keeping current community plans required by Section 4 of this Act.]

(k) For purposes of this Act, the Department is authorized to accept and administer Federal grants.

(l) For purposes of this Act, the Department shall cooperate with all appropriate Federal, State, interstate, and local units of government, and with appropriate private organizations.

5. This period should be the same as that fixed in Section 5 (c) (2). See footnote 4.
6. See footnote 5.
7. This requirement should be consistent with the general practice for publication requirements in the State and with any State administrative procedure act which may apply.
8. If administrative hearings on appeals from actions of the Department be not provided for under other State laws, a section on appeals and judicial review should be added.

Section 6. Conformance to Approved Community Plan.

(a) The Department shall prescribe the time within which each municipality within areas designated under Section 5 of this Act shall submit a community plan, amendment, or revision thereof. Such time for the initial submission of a community plan shall not be greater than one year from the date of designation of such area, except that the Department may extend such time for good cause shown.

(b) Within six months after the submission of a community plan, amendment, or revision thereof, or six months after the time prescribed in Subsection (a) of this Section for the submission of a community plan, amendment, or revision thereof, whichever is earlier, the Department shall approve or disapprove the community plan, amendment, or revision thereof. Any community plan, amendment, or revision thereof which has been submitted in accordance with this Section and which has not been disapproved by the Department within the time required by this Section shall be deemed to be approved.

(c) After nine months following the submission of a community plan, amendment, or revision thereof, or nine months following the time within which a community plan, amendment, or revision thereof is required to be submitted under Subsection (a) of this Section, whichever is earlier, or after such later date as may be established by the Department for good cause shown, no community water supply system or community sewerage system, or individual water supply system or individual sewerage system may be installed in those geographic areas to which such community plan, amendment, or revision thereof relates unless a community plan and any required amendments or revisions have been approved for such areas, and such system and installation be consistent with such community plan including any required amendment and revision thereof and with applicable rules and regulations.

(d) No State or local authority empowered to grant building permits or to approve subdivision plans, maps, or plats shall grant any such permit or approve any such plan, map, or plat which provides for individual or community water supply systems or sewerage systems unless such systems be found to be in conformance with the community plan, amendments, and revisions thereof approved by the Department and applicable rules and regulations.[9] As a condition of such approval, the transfer of community systems to a municipality may be required by [appropriate State or municipal authority] in accordance with applicable provisions of State law as to compensation.

(e) Applicants for building permits and subdivision approvals, and water supply systems and sewerage systems construction approval, shall submit to the approving authority such information in such form as may be reasonably necessary and required to show compliance with Subsection (c) of this Section.

(f) Any violation of Subsection (c) of this Section shall be punishable by a fine not to exceed $_____.[10] The imposition of any such fine shall not bar any other relief or penalty otherwise applicable.

Section 7. Exclusion. Nothing in this Act shall be construed to prohibit the installation or operation of water supply systems used solely for purposes not requiring potable water.

Section 8. Appropriation. There is appropriated $_____ to cover necessary expenses of the Department in administering this Act.

Section 9. Conflict with Other Laws. The provisions of any zoning ordinance, subdivision regulation, building code, or other law or regulation of any municipality of the State establishing standards designed to afford greater protection to the public health, safety, and welfare of the community shall not be limited or superceded by regulations adopted pursuant to this Act within the area over which the municipality has jurisdiction.

9. See footnote 8.

10. Penalty under this Act should be consistent with penalities under subdivision regulations and building codes within the State. A commonly used penalty is $100 with any persistent condition constituting a new violation each day it continues.

Chapter XI

Individual Water Supply Systems *

Although the sanitary technology for extraction of ground water for individual water supply systems was mainly developed by engineers, this technology, generally, is of a nature which can be handled by well trained sanitarians. The apparatus for wells have become more or less standardized and can be bought as units with detailed instructions for installation, and the construction of cisterns and the housing for springs are not complicated engineering problems. Therefore, with a sufficient knowledge of the earths strata as related to its water bearing properties, with an understanding of the bacteriological, chemical and physical qualities of water, and adequate training in the technology of ground water extraction, the sanitarian should be able to judge the adequacy of plans and installations of rural and other individual water supplies. When special circumstance present themselves, the sanitarian, with broad knowledge of the subject, can understand when engineering consultation is needed.

In rural and other areas where individual water supply systems are used, rain water and ground water are the usual sources of supply, since these sources are much less disposed to pollution and contamination than surface water. Surface water becomes greatly purified as it percolates through fine sandy soil. This is nature's process of filtration; the organic matter is oxidized and the bacteria are largely strained out. The soil can take care of a large amount of pollution, and if not overburdened, or if it has no cracks or crevices through which surface water may run unfiltered, the ground water may be entirely free of objectionable organic substances and bacteria. In passing through the soil, the water takes up a rather large amount of carbon dioxide, which is set free by organic decomposition. This water, thus made acid (since CO_2 in water forms carbonic acid), has greater solvent action for lime and other mineral constituents so that ground water is apt to be harder than surface water and to contain a larger amount of dissolved inorganic substances. In deeper waters the solvent action is favored by increased contact with geological formations, so that deep wells and artesian waters are frequently unfit, unless treated, for domestic use on acccount of the large amount of lime, iron, salt, and other inorganic matter which they contain. In other instances, however, such wells produce water of excellent quality.

Rain Water: Rain water is really "distilled water", that is, it is water that has been vaporized and then condensed. The process of distillation is one of the best known methods for purifying liquids of all kinds, therefore rain water should approach nearer to absolute purity than any other kind of natural water. However, it receives impurities from the moment it condenses, for each droplet of mist is formed about a particle of dust in the air. The rain drop further absorbs gases, near the sea-coast it dissolves suspended salts, and as it drops through the air it collects a large amount of the "dirt" floating in the lower strata of the atmosphere. If collected from an impervious surface such as a good roof on a farm house after wasting the first run off and preferably passing the subsequent flow through a sand filter, it is very pure natural water. However, the use of rain water for drinking purposes has met with little favor by sanitarians because it is so frequently collected and stored in such careless manner that it is subject to pollution.

Much of the snow, hail, or sleet falling on a water shed is kept in storage on the ground surface until temperatures rise above freezing. In mountainous areas, snow storage may be an important source of water supply. In such cases, measures taken to increase the snow pack and reduce the melt rate could be beneficial to individual water supply systems in the area.

Because rain water is soft it recommends itself for use in the laundry, and the absence of lime salts renders it desirable for cooking. On the whole, however, it is not considered as practicable as the good ground or surface water for general domestic supply. The taste, also, is more or less "flat".

Usually it is advisable to filter rain water collected from roofs of buildings, especially if situated in towns, near dusty roads, etc., as was mentioned before.

*Reference: Manual of Individual Water Supply Systems, Public Health Service Publication No. 24, (Revised 1962).

The points of prime importance in the collection and storage of rain water for domestic purposes are:

1. The material and care of the surface upon which it is caught.

2. The separation of the first flow which contains most of the gross impurities.

3. The location and construction of the storage cistern.

Tanks of wood serve well, provided they be kept full and free from foreign matter like dead leaves, insects, etc. Great fluctuation of the water line causes the tank to fall into disrepair. Rain water attacks iron, lead, zinc, and other metals; therefore, metal cisterns and delivery pipes should be coated with a good asphaltum paint. Lead cisterns or pipes should be used under no circumstances. Frequent cleaning of cistern is important.

Rain water contains the following gases: Nitrogen, oxygen, carbon dioxide, ammonia.

The principle inorganic constituents are: Sodium chloride (comes from sea-spray carried in wind), nitric acid and nitrates, sulfuric acid and sulphates (waste products of coal burning).

Ground Water: It might be well to follow the water through its cycle of movement in order to gain a more vivid picture of its interesting course (Fig. 1).

1. Moisture in atmosphere is precipitated to form rain.

2. Rain water runs along the surface of the earth.

3. Part of the rain water runs into lakes and streams, part is evaporated, part soaks into the ground.

4. Part of the ground water is taken up by vegetation and is transferred by plants into the atmosphere; part of the water is stored in the plant and returned to the ground or atmosphere after the plant dies.

5. Part of the water in the ground passes easily through the upper layers of the earth which are less dense and have a certain amount of air (and therefore oxygen) in their porous structure. This is known as the Zone of Aeration (Fig. 1), and in it organic material is oxidized mostly by bacterial action into organic constituents of the earth. At the same time the porous nature of the soil acts as a natural filter of bacteria.

6. The Zone of Aeration is kept moist by water that is adsorbed to the particles of earth. This water is known as Pellicular Water; other water which continues to pass downward is called Gravity Water.

7. As the water continues to pass downward, the ground becomes denser and more impervious and therefore the water accumulated and saturates the ground. This saturated area is known as the Zone of Saturation. Water in the zone of saturation is called Ground Water. Between the zone of saturation and zone of aeration is a fringe where water is held by capillary action. This is called the Capillary Fringe and corresponds to a narrow stratum just above the Water Table. The Capillary Fringe is not a source of supply since the water held will not drain freely by gravity. If the upper surface of the zone of saturation be not confined by impermeably material, this is the Water Table. It is the stratum just below the capillary fringe and forms the upper layer of the zone of saturation where the water ceases to pass downward and is

directed instead along a horizontal plane, forming a more or less continuous bed of water in the porous stratum. This water table underlies practically all of the earth's surface. Sometimes it is close to the surface and sometimes it is deep, depending upon the amount of rain, types of strata in the earth, etc. The water level more or less conforms to the slope of the earth's surface. Where the water table stratum emerges to the surface of the earth, Springs occur. Where the beds of streams are in the saturated zone, the streams receive water from it. The water table may fluctuate through periods of drought and rain, but is otherwise stabilized by discharging as springs or into beds of streams or lakes. A well is merely a hole dug deep enough to reach the zone of saturation. The height of water in the well corresponds to the level of the water table.

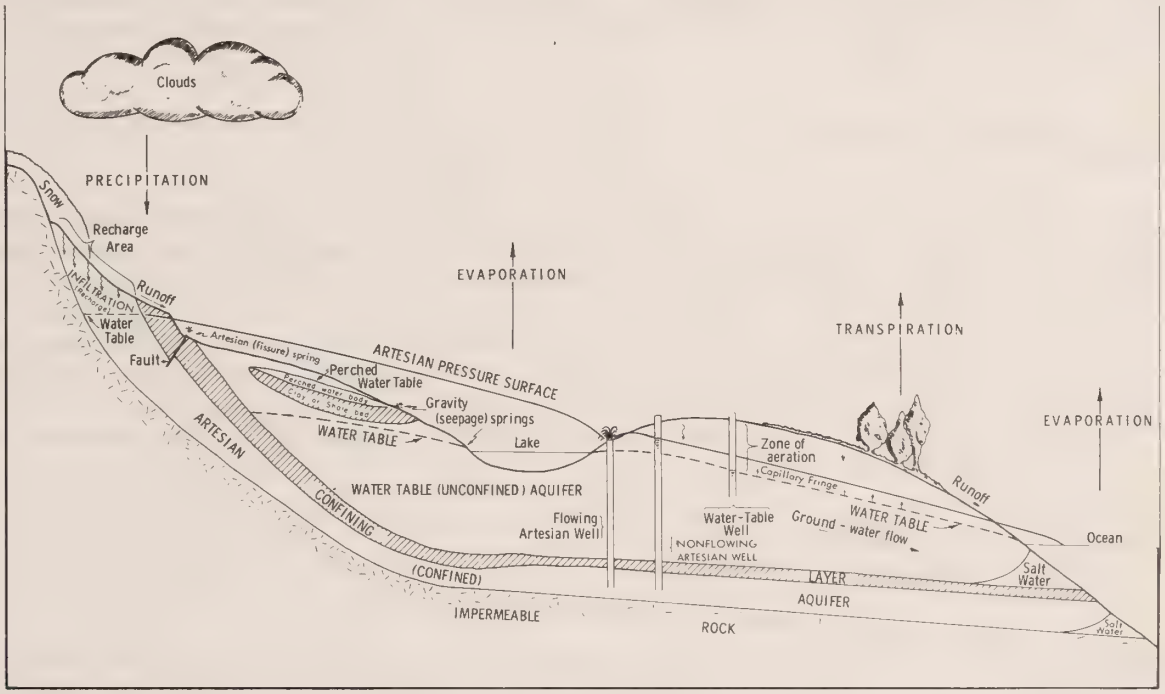

Figure 1. Hydrologic Cycle.

8. When an overlying impermeable formation confines the water in the zone of saturation under a pressure greater than atmospheric pressure, the ground water is under Artesian Pressure. The name, artesian, comes from the ancient province of Artesium in France where, in the days of the Romans, water flowed to the surface of the ground from a well. Not all water from wells that penetrate artesian formations flows above the surface of the land. For a well to be artesian, the water in the well must stand above the top of the Aquifer. An Aquifer or water-bearing formation or ground water reservoir is an underground layer of permeable rock or soil which permits the passage of water.

Because of the irregularities in underground deposits and in surface topography, the water table occasionally intersects the surface of the ground or the bed of a stream, lake, or ocean. As a result, ground water moves to these locations and out of the aquifer or ground-water reservoir. Thus, ground water is continually moving within the aquifer even though the movement may be slow.

The water table or artesian pressure surface slopes from areas of recharge to areas of discharge. (The area of recharge is when the water filters into the earth to the aquifer.) The pressure differences represented by these slopes cause the flow of ground water within the aquifer. At any point on the slope, the rate of flow and resistance to movement of water through the zone of saturation determines the status of the underground water. Seasonal variations in the supply of water to the underground reservoir cause considerable changes in the elevation and slope of the water table and artesian pressure level.

9. The water cycle is complete now. Well water and spring water find their way from the ground again and finally are evaporated to form the moisture in the atmosphere, the clouds and the rain.

Ground Water is water which is taken from the ground by means of wells or that flows naturally from the ground such as springs. These are usually greatly purified waters due to natural filtration. Where the ground is not porous the water may be dangerous for domestic use.

Many processes are constantly at work to prevent the accumulation of contamination underground. Among the factors mentioned by Stiles and Crohurst as having a bearing upon the undergroung accumulation of bacteria are the hydrogen-ion concentration of the soil, the effect of drying because of changes in the level of the ground water, competition between bacteria, protozoan and other organismal competition, temperature, the presence or absence of a food supply, the natural death rate of bacteria, the effect of capillarity which may carry bacteria into the capillary fringe where they may die by drying, and the accumulation of the bacteria near the water table where they may subsequently be unwatered by the lowering of the water table and be killed in drying.

The chief factors bearing upon the contamination of ground water supplies as related to location are:

1. The nature of the earth's formations with respect to the freedom with which water can move toward the well or spring, and also with respect to the character of soil and geological formations at the surface, such as porosity, uniformity, size of material, stratification, rock solution, channels, faults, acidity or alkalinity and similar conditions which may affect the underground water, and the manner and rate of spread of bacteria as discussed subsequently.
2. Rate and direction of the movement of ground water as related to degree and direction of slope of land and the water table, and distance from source of contamination.
3. Mode of occurrence of ground water - whether water be obtained from zones near the water table or from artesian zones.
4. Rate of pumping.
5. Flooding and drainage.
6. Toilets, floor drains, etc.
7. Pits.

Quality of Water. The quality of water is determined by various physical and chemical characteristics, and biological and radiological factors. Standards for these have been developed and incorporated into the U. S. Public Health Service (1962) Drinking Water Standards. These are discussed in the chapters on Quality of Drinking Water, Public Water Supply, and Control of Radiation Hazards.

Consideration of Water Usages

Lawn Sprinkling: The amount of water required for lawn sprinkling depends upon the size of the lawn, type of sprinkling equipment, climate, soil, and water control. In dry or arid areas the amount of water required may equal or exceed the total used for domestic or farstead needs. When lawn watering in relation to other water uses is small, the water requirements can be estimated. For estimating purposes, a rate of approximately 1/2 inch per hour of surface area is reasonable. This amount of water can be applied by sprinkling 30 gallons of water per hour over each 100 square feet.

Example: $\frac{1000}{100} \times 30 = 300$ gallons per hour or 5 gpm.

A lawn of 1000 square feet would require 300 gallons per hour.

When possible the water system should have a minimum capacity of 500-600 gallons per hour. A water system of this size may be able to operate satisfactorily during a peak demand. Peak flows can be estimated by adding lawn sprinkling to peak domestic flows but not to fire flows.

Fire Protection: In areas of individual water supply systems, effective firefighting depends upon the facilities provided by the property owner. The National Fire Protection Association

has prepared a report which outlines and describes ways to utilize available water supplies.*

The most important factors in successful firefighting are early discovery and immediate action. For immediate protection portable fire extinguishers are desirable. Such first aid protection is designed only for the control of fires in the early stage; therefore, a water supply is desirable as a second line of defense.

The use of gravity water supplies for firefighting presents certain basic problems. These include (1) the construction of a dam, farm pond, or storage tank to hold the water until needed and (2) the determination of the size of pipeline installed from the supply. The size of the pipe is dependent upon two factors: (1) the total fall or head from the point of supply to the point of use and (2) the length of pipeline required.

Wells can serve as a source of water for both domestic and firefighting purposes. A well should be capable of supplying 8-10 gallons per minute for a period of 2 hours daily throughout the year. Drilled, deep wells are the most dependable for firefighting, drawing their supply from extensive aquifers. The slightly greater cost of a 6-inch drilled well is easily justified by the increased supply made available. Wells should be tested for yield by pumping for a period of at least 2 hours. The results of the test will indicate the equipment to be purchased.

The smallest commercial water pressure systems have a capacity of 210 gallons an hour (3 1/2 gallons per minute) or even less. While this will furnish a stream, through ordinary garden hose, of some value in combating incipient fires or in wetting down adjacent buildings, it cannot be expected to be effective on a fire which has gained any headway. When such systems are already installed, connections and hose should be provided. When a new system is being planned or a replacement of equipment made, it is urged that a capacity of at least 500 gallons an hour (8-1/3 gallons per minute) be specified and the supply increased to meet this demand. If necessary, storage should be added. The additional cost for the larger unit necessary for fire protection is partially offset by the increased quantities of water available for other uses.

Sanitary Survey of Water Supplies

The importance of a sanitary survey of water sources cannot be over-emphasized. With a new supply, the sanitary survey should be made in conjunction with the collection of initial engineering data covering the development of a given source and its capacity to meet existing and future needs. The sanitary survey should include the detection of all health hazards and the assessment of their present and future importance. Persons trained and competent in public health engineering and the epidemiology of waterborne diseases should conduct the sanitary survey. In the case of an existing supply, the sanitary survey should be made at a frequency compatible with the control of the health hazards and the maintenance of a good sanitary quality.

The information furnished by the sanitary survey is essential to complete interpretation of bacteriological and frequently the chemical data. This information should always accompany the laboratory findings. The following outline covers the essential factors which should be investigated or considered in a sanitary survey. Not all of the items are pertinent to any one supply and, in some cases, items not in the list would be important additions to the survey list.

Ground-Water Supplies

a. Character of local geology; slope of ground surface.
b. Nature of soil and underlying porous strata whether clay, sand, gravel, rock (especially porous limestone); coarseness of sand or gravel; thickness of water-bearing stratum; depth to water table; location and log of local wells in use or abandoned.

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*National Fire Protection Association, "Water Systems for Fire Protection on Farms," National Fire Codes, Vol. IV (Boston, 1946).

Table 1.—*Planning guide for water use*

Types of establishments	Gallons per day
Airports (per passenger)	3–5
Apartments, multiple family (per resident)	60
Bath houses (per bather)	10
Camps:	
Construction, semipermanent (per worker)	50
Day with no meals served (per camper)	15
Luxury (per camper)	100–150
Resorts, day and night, with limited plumbing (per camper)	50
Tourist with central bath and toilet facilities (per person)	35
Cottages with seasonal occupancy (per resident)	50
Courts, tourist with individual bath units (per person)	50
Clubs:	
Country (per resident member)	100
Country (per nonresident member present)	25
Dwellings:	
Boarding houses (per boarder)	50
Additional kitchen requirements for nonresident boarders	10
Luxury (per person)	100–150
Multiple family apartments (per resident)	40
Rooming houses (per resident)	60
Single family (per resident)	50–75
Estates (per resident)	100–150
Factories (gallons per person per shift)	15–35
Hotels with private baths (two persons per room)	60
Hotels without private baths (per person)	50
Institutions other than hospitals (per person)	75–125
Hospitals (per bed)	250–400
Laundries, self-serviced (gallons per washing, i.e., per customer)	50
Livestock (per animal):	
Cattle (drinking)	12
Dairy (drinking and servicing)	35
Goat (drinking)	2
Hog (drinking)	4
Horse (drinking)	12
Mule (drinking)	12
Sheep (drinking)	2
Steer (drinking)	12

Types of establishments	Gallons per day
Motels with bath, toilet, and kitchen facilities (per bed space)	50
With bed and toilet (per bed space)	40
Parks:	
Overnight with flush toilets (per camper)	25
Trailers with individual bath units (per camper)	50
Picnic:	
With bath houses, showers, and flush toilets (per picnicker)	20
With toilet facilities only (gal. per picnicker)	10
Poultry:	
Chickens (per 100)	5–10
Turkeys (per 100)	10–18
Restaurants with toilet facilities (per patron)	7–10
Without toilet facilities (per patron)	2½–3
With bars and cocktail lounge (additional quantity per patron)	2
Schools:	
Boarding (per pupil)	75–100
Day with cafeteria, gymnasiums, and showers (per pupil)	25
Day with cafeteria but no gymnasiums or showers (per pupil)	20
Day without cafeteria, gymnasiums, or showers (per pupil)	15
Service Stations (per vehicle)	10
Stores (per toilet room)	400
Swimming pools (per swimmer)	10
Theaters:	
Drive-in (per car space)	5
Movie (per auditorium seat)	5
Workers:	
Construction (per person per shift)	50
Day (school or offices per person per shift)	15

Table 2.—*Rates of flow for certain plumbing, household, and farm fixtures*

Location	Flow pressure[1]—pounds per square inch (psi)	Flow rate—gallons per minute (gpm)
Ordinary basin faucet	8	2. 0
Self-closing basin faucet	8	2. 5
Sink faucet, ⅜ inch	8	4. 5
Sink faucet, ½ inch	8	4. 5
Bathtub faucet	8	6. 0
Laundry tub faucet, ½ inch	8	5. 0
Shower	8	5. 0
Ball-cock for closet	8	3. 0
Flush valve for closet	15	[2] 15–40
Flushometer valve for urinal	15	15. 0
Garden hose (50 ft., ¾-inch sill cock)	30	5. 0
Garden hose (50 ft., ⅝-inch outlet)	15	3. 33
Drinking fountains	15	0. 75
Fire hose 1½ inches, ½-inch nozzle	30	40. 0

[1] Flow pressure is the pressure in the supply near the faucet or water outlet while the faucet or water outlet is wide open and flowing.

[2] Wide range due to variation in design and type of closet flush valves.

c. Slope of water table, preferably as determined from observational wells or as indicated, presumptively but not certainly, by slope of ground surface.

d. Extent of drainage area likely to contribute water to the supply.

e. Nature, distance, and direction of local sources of pollution.

f. Possibility of surface-drainage water entering the supply and of wells becoming flooded; methods of protection.

g. Methods used for protecting the supply against pollution by means of sewage treatment, waste disposal, and the like.

h. Well construction: material, diameter, depth of casing; depth to well screens or perforations; length of well screens or perforations.

i. Protection of well at top and on sides.

j. Pumphouse construction (floors, drains, etc.); capacity of pumps; drawdown when pumps are in operation.

k. Availability of an unsafe supply, usable in place of normal supply, hence involving danger to the public health.

l. Disinfection: equipment, supervision, test kits, or other types of laboratory control.

Surface-Water Supplies

a. Nature of surface geology; character of soils and rocks.

b. Character of vegetation; forests; cultivated and irrigated land, including salinity, effect on irrigation water, etc.

c. Population and sewered population per square mile of catchment area.

d. Methods of sewage disposal, whether by diversion from watershed or by treatment.

e. Character and efficiency of sewage-treatment works on watershed.

f. Proximity of sources of fecal pollution to intake of water supply.

g. Proximity, sources, and character of industrial wastes, oil field brines, acid mine waters, etc.

h. Adequacy of supply as to quantity.

i. For lake or reservoir supplies; wind direction and velocity data; drift of pollution; sunshine data (algae).

j. Character and quality of raw water: coliform organisms (MPN), algae, turbidity, color, objectionable mineral constituents.

k. Nominal period of detention in reservoir or storage basin.

l. Probable minimum time required for water to flow from sources of pollution to reservoir and through reservoir intake.

m. Shape of reservoir, with reference to possible currents of water, induced by wind or reservoir discharge, from inlet to water-supply intake.

n. Protective measures in connection with the use of watershed to control fishing, boating, landing of airplanes, swimming, wading, ice cutting, permitting animals on marginal shore areas and in or upon the water, etc.

o. Efficiency and constancy of policing.

p. Treatment of water: kind and adequacy of equipment; duplication of parts; effectiveness of treatment; adequacy of supervision and testing; contact period after disinfection; free chlorine residuals carried.

q. Pumping facilities: pumphouse, pump capacity and standby units, storage facilities.

Classification of Rocks as Related to Water-bearing Properties.

Rocks may be classified with respect to their origin into three classes - sedimentary rocks, igneous rocks, and metamorphic rocks. The markedly different sources of origin of these classes produce rocks of radically different charcter and hence considerable difference in their water-bearing properties.

Sedimentary rocks are derived from older rocks by weathering and erosion--as, for example, by the deposition of gravel, sand silt, and clay, by the deposition of calcareous and siliceous remains of animals, as in most of the limestones, marls, and related rocks, or by the chemical deposition of substances precipitated from solution, as in much of the flint and chert, caliche and some other limestones, gypsum, and slate. Rocks of sedimentary origin include formations that are among our best water bearers - as, for example, gravel, sand, sandstone, and creviced limestone.

Igneous rocks are produced by the cooling and solidification of molten masses of material from great depths below the surface. These rocks differ widely in texture and water bearing properties. Most of the igneous rocks that are now at the surface were solidified far below the surface and were originally very compact and nearly impervious -- as, for example, unweathered granite. Water in quantities sufficient for well supplies occurs in such rocks largely in the joints and in the weathered superficial parts of the rocks. They are generally not profuse water-bearers. The lavas poured out upon the surface may, however, be so broken and vesicular that they will yield water in great abundance -- as, for example, many of the basalts of the northwestern states and Hawaii. Upon weathering these extrusive rocks become more compact and less permeable.

Metamorphic rocks are produced by the marked alteration of other rocks, chiefly at great depths, through the agency of heat and pressure. The principle rocks of this class are quartzite, slate, marble, schist, and gneiss. The metamorphic rocks are generally compact and nearly impervious, and they yield only meager supplies of water, chiefly from their joints, crevices, and cleavage planes or from the superficial weathered parts of the rocks.

The most abundant sources of ground water may be obtained from: Sand and gravel deposits, sandstone rock, limestone formations.

The size, shape, and interrelations of the interstices in the rocks are of primary importance in determining the bacteriologic quality of the water that accumulated below the ground-water table and supplies the wells and springs, for they determine largely the rapidity with which water may pass through a formation and the ability of the formation to filter out pollution. Formations that exert great filtering action on water passing through them such as most formations of sand or sandstone, furnish the greatest protection against the transmission of contamination and pollution. On the other hand, formations that contain fissures and joints, large interstices, as in coarse, clean gravel, or solution channels, as in the creviced limestones, provide little filtering action and, moreover, may allow the water to move rapidly. Such formations may carry contamination long distance from the original sources.

One of the best formations to yield water in abundance is clean, coarse gravel. It possesses all the essential characteristics of an excellent water-bearing rock, for it absorbs water freely, stores water in great volume, and yields water freely to wells. In this material there is essentially no water in the individual pieces of rock, but because the openings between the pieces are large and connected with one another, water may move freely through it. However, as stated, little filtering action on the water is provided, and hence, contamination can move through the gravel readily.

If the void space of gravel be filled with material of smaller size, such as sand, the water moves less freely than in the clean, course gravel. Because the voids are smaller, the filtering action is correspondingly increased. Therefore, great protection against the transmission of contamination is afforded. Obviously, a formation composed of sand alone provides maximum filtering action, and clean sands are classed in the group of rocks that afford the greatest safety from contamination. However, if the individual sand grains be very small the resistance to the movement of the water may be so great that the formation will not yield much water. A true clay has extremely small interstices. Even though its porosity* may be greater than that of many deposits of sand or gravel, little or no water moves through it because of the fineness of the particles and the minuteness of the water-filled interstices which cause a great resistance against the movement of the water. Clay is classed as nonwater-producing material and is especially favorable to seat a well casing that is intended to exclude surface contamination or undesirable ground water.

Between the clean sand deposits through which water moves freely, and the non-water-bearing clays, there is a large miscellaneous group of materials composed of mixtures of coarse and fine material but predominantly clayey. Of such character are the poorly assorted materials of till or boulder clay that were laid down by glacial ice, many of the alluvial deposits formed under very changeable conditions, and most of the residual materials produced by the weathering of igneous and metamorphic rocks. Such materials will not generally yield much water, but in many sections where they lie near the surface they yield small supplies to dug wells. However, because the water supplies to the wells may be transmitted largely through small crevices, these materials do not provide the maximum protection against pollution.

When individual grains of a deposit of sand become cemented together and the deposit becomes more or less hardened the formation is called a sandstone. As long as the interstices are not completely filled, sandstone has the same general properties as incoherent sand with respect to the movement of both water and contamination. If the interstices be completely filled, the sandstone becomes essentially impervious, and any water that occurs in it in sufficient quantity to be useful as a source of water supply is found in fissures, crevices, and joints. In addition to hard sandstone, other rocks that contain water largely in fissures, crevices, and joints are trap rock, and most of the metamorphic rocks, such as quartzite, slate, gneiss, and chist. Because the joints, fissures, and crevices provide little filtering action to water passing through them, contamination can be transmitted for considerable distances through these rocks, although not as readily as through creviced limestone, broken lava rock, or coarse, clean gravel. Unweathered extrusive lava rocks may yield water chiefly from large openings that permit very free circulation of water. These openings may be due to the broken condition of the rocks or to the expansion of steam or other gas when pressure was removed during the process of cooling. The largest opening may consist of caverns and tunnels formed during the process of congealing from a molten state.

Unweathered limestone may be porous and permeable but it generally contains numerous crevices, cavities, and channels that have resulted from the solution of portions of the rock by water that penetrated pre-existing openings. Some of these openings have attained enormous size, as in the large caverns that are so common in limestone regions. Limestones may yield very large quantities of water from such openings. Because the large openings in both lava and limestone afford almost no filtering action, contamination can be transmitted through them freely for great distances. Such waters hold a large amount of calcium bicarbonates and are very hard.

* $\frac{\text{Volume of interstices}}{\text{Volume of mass}}$ = Porosity

Rate and Direction of Movement of Ground Water

Ground water generally moves from an area of surface intake to an area of natural discharge except as it is diverted toward wells that are pumped or flow by artesion pressure. This movement is the result of difference of head in the ground water system and is in the direction of the slope of the water-table or in the direction of the hydraulic gradient in an artesian system for pumped wells. The contour of the water-table can be determined by measurements of the depth to the water in a sufficient number of wells that are not affected by draw-down through pumping and by referring such measurements to sea level or other plane of reference. In most parts of humid regions the water-table is built up from time to time by water penetrating from the surface during periods of heavy rain or in the spring when the frost leaves the ground. Natural discharge of the ground water, however, occurs only in low places. In humid regions, therefore, the water-table generally slopes in nearly the same direction as the land surface, except where conditions have been modified by drainage, pumping from wells, or other agencies, or faults in geological ground formations.

In an undeveloped ground-water basin, percolation of water to lower basins, seepage from and to surface-water sources, and transpiration are dependent upon the water in storage and rate of recharge. During periods following abundant rainfall, recharge may exceed discharge. When recharge exceeds discharge, the excess rainfall increases the amount of water available in storage in the ground-water basin. As the water table or artesian pressure rises, the gradients to points of discharge become steeper and outflow increase. When recharge ceases, storage decrease from outflow causes water-table levels and artesian pressure to decline. In most undeveloped basins the major fluctuations in storage are seasonal, with the mean annual elevation of water levels showing little variation. Thus, the average annual inflow to storage equals the average annual outflow, a quantity of water referred to as the basin yield.

The proper development of a ground-water source requires careful consideration of the hydrological and geological conditions of the area. The individual who wishes to take full advantage of a water source for domestic use should obtain the assistance of a qualified engineer, geologist, or contractor familiar with the construction of wells in his area. He should rely on facts and experience, not on instinct and intuition. Facts on the geology and hydrology of an area may be available in publications of the U. S. Geological Survey or from other Federal and State agencies.

The direction of the movement of the ground is an important factor in connection with the transmission of contamination. As already stated, it is well established that contamination moves in the same direction as the ground water, and hence, as a general rule, wells should be installed up the slope and not down the slope of the water from possible sources of contamination.

The rate of movement of the ground water has an important relation to the transmission of contamination from its source of the wells. However, definite data on the transmission of contamination by ground water are comparatively meager. Obviously the bacteriologic control of experiments to determine the rate of transmission is extremely difficult. It is fairly well established, however, that the great body of ground water is generally free from dangerous pollution except near the water-table in the proximity of polluting agencies and except in very open rocks, such as cavernous limestone, extrusive lava rock, or coarse, clean gravel, in which contamination may be carried long distances. Experiments by Stiles and his assistants fully support this conclusion. Recognition of these general facts will aid greatly in adopting a safe practice in ground-water developments. Fortunately, small water supplies, such as are furnished by individual farm or domestic wells, are drawn from relatively small areas and can generally be made safe by locating the well up the slope and as far as practicable from possible sources of contamination and by proper well construction. Wells that are heavily pumped, as in public waterworks, draw their supplies from greater distances, and therefore greater precautions are required to assure safety.

The horizontal distance from any source of contamination should not be less than 50 feet, but this distance should be used only where ideal conditions indicate it to be sufficient; a greater distance should be required where local conditions demand such. As will be explained later,

this distance may be reduced to 30 feet in case additional protection is provided. If satisfactory sites be not available, adequate treatment of the water should be provided.

C. W. Stiles and Associates of the United States Public Health Service published in 1923 their investigations into methods of disposal of privy wastes in rural districts. Extensive and rigorously controlled experiments had been made which bear upon the subject at issue and especially upon the movement of bacteria, of fecal origin, in the ground water. The experimental contamination of the ground-water was studied in relation to the rise and fall of the ground-water-table, the flow of ground-water, and the rainfall. Human excreta from can type privies was used as pollution material. Escherichia Coli was taken as the bacterial test, and dye (uranin) was utilized in tracing the movement of the water from the dosing trenches to the more than 400 experimental pipe wells which were arranged at intervals from the trenches and at various depths into ground water.

The examination of thousands of water samples from the wells during a period of more than a year had resulted in very definite data which seems to express practically a natural law as applied to the movement of the bacteria in the field of fine sand in which the experiments were conducted. The results may be summarized as follows:

1. Contamination with Escherichia Coli had been definitely and progressively followed in the ground-water for distances of 3, 6, 10, 15, 25, 35, 45, 50, 55, 60, 65 feet from the trench in which the pollution was placed; uranin had been recovered from these same wells at 70, 75, 80, 85, 90, 95, 100, 110, and 115 feet from the pollution trench. The soil in question was a fine sand and an effective size of 0.13 mm.

2. The pollution traveled these distances within a period of 187 days, or about 27 weeks, and only in the direction of the flow of the ground-water; no convincing evidence was present that the pollution against the flow of the ground-water or at right angles to it took place.

3. The pollution traveled only in a thin sheet at the surface of the zone of saturation; there was no evidence that it dispersed radially downward, and even heavy pollution was recovered at the top, water from lower levels (in near-by deeper wells) being negative both for uranin and for Escherichia Coli.

4. As the ground-water level fell, owing to the dry weather, the pollution tended to remain in the sand above the new (lower) ground-water level, namely, in the new capillary fringe.

5. There was no evidence which would justify a conclusion that either the bacteria or the uranin was carried or moved to any appreciable distance in the capillary fringe itself, and there was neither theoretical reason nor experimental evidence to justify a conclusion that either the bacteria or the uranin progressed in the dry, aerated intermediate belt (between the capillary fringe and the upper soil belt.) All present evidence is to the effect that when the ground-water level falls the pollution remains practically stranded in the capillary fringe or in the intermediate belt according to the degree of fall of the ground-water.

6. A rainfall of 1 inch resulted in a rise of 5 to 6 inches in the ground-water-table (in the particular experimental area in question); and if this rise were sufficient to reestablish the zone of saturation up at the level of the stranded pollution, the bacteria and the uranin were again picked up and carried along farther in the direction of the ground-water flow until dry weather again intervened to cause another fall of the ground-water level.

7. Thus the progressive (passive) movement and the stasis (stranding) of the pollution were intimately connected with, were depended upon, and alternated with the rise and fall of the ground-water level, and this latter factor was dependent upon the alternation of wet weather (rainfall) and dry weather (lack of rain at the intake area of the ground-water table.)

8. In explaining these results, capillarity, filtration, and gravity seem to come up for special consideration.

9. In one experiment the pollution traveled only 45 feet from September , 1922 to May, 1923 and remained stranded at this distance. Study of the formation of the ground revealed that under the belt of pollution there was an impervious or nearly impervious stratum of peatlike material which gradually tilted upward distally from the pollution pit and formed a ground-water dam; the pollution traveled out on high ground to the dam, the ground-water level fell below the crest of the dam, and the pollution was stranded, pending a rise of the ground-water-table sufficient to produce a ground-water cascade which would carry the pollution over the crest of the dam.

10. The ultimate distance to which pollution will be carried is dependent upon a number of complex and interesting factors, namely, wet and dry weather with resulting rise and fall of the ground-water; the length of each of these periods; the rate of the ground-water flow (depending upon the "head" which, in turn, is dependent upon the rainfall); and, obviously, also, the factor of the viability of the organisms under conditions of moisture, pH, food supply, etc.

11. In another series of experiments human feces were buried in pits in a locality of high ground-water, and covered with sawdust. Of five samples taken three years and two months after burial all were both microscopically recognizable as feces, but the odor had become musty. Three of these samples were positive and two were negative for Escherichia Coli. Ova of Ascaris lumbricoides were recognizable in all five samples, but all 57 ova found were dead.

12. The bearing of the foregoing results upon the intermittent pollution of wells, the location of water supplies, and the location of camps in peace or in war, will be evident to persons who are called upon for technical advice in these matters. The justification of laws forbidding the use of abandoned wells for the disposal of excreta is self-evident; the possible effect of the custom (in some localities) of digging into ground-water is obvious.

13. In protecting wells, special attention should be given not only to surface protection as is now generally recognized but also to a new element, namely, the danger zone which exists from the higher water level to about a foot below the lowest water level. A leak in the pipe in this region is potentially very dangerous, and all wells unprotected in this danger zone are to be considered as potentially unsafe.

Other important investigations on ground-water pollution caused by latrines were made by E. L. Caldwell and L. W. Parr of the Field Research Laboratory, Alabama State Health Department and published in 1937-38. The experiments included testing contamination in ground water flow, testing contamination without a ground-water flow, and measuring ground water flow. The experiments were performed by boring a number of latrines in sandy and clayey soils 15 inches in diameter encircled by bored test wells. The latrines extended into the ground-water flowing in the unconsolidated soil. Closely underlying the latrines and ground-water flow there was an impervious stratum of earth. The latrines and test wells were operated at a rate resembling household use.

The investigations showed that typical E. Coli and chemical products were obtained only from wells in or near the flow of sewage from a latrine, which flow traveled with the ground-water flow. Certain of these wells consistently yielded chemical pollution but no fecal organisma. This emphasized the importance of the "defense" mechanism developed in the soil against bacterial spread resulting from latrines and in filtration beds as the pores of the soil become clogged with organic materials, thus allowing time for the organisms to die before being transported very far.

A brief summary of the more important findings and conclusions are given below:

1. Lineal and depth recovery of pollution in relation to conditions:

(a) Upon first addition of excreta, chemical products were not sufficiently concentrated to be detected when E. Coli were carried 5 feet through the lower strata at the rate of ground-water flow (about 5 feet per day) and a few had reached 15 feet in three days. Thereafter readily perceptible chemical pollution preceded all bacterial recovery and was evident at 35 feet in 9 days. In the upper stratum (at the rate of 3 feet per day), E. Coli did not appear at 10 feet before 5 weeks, though chemical pollution was evident in 4 days. That is, the initial advance is a function of velocity and concentration.

(b) As the sewage increased in the latrine and was thoroughly distributed during marked septic action in summer heat, fecal organisms in the filtration area also were augmented. After two months, E. Coli were present at peak recovery in 90 percent of samples at 15 feet, appeared in 10 cc. volumes at 25 feet for a month in 40 percent of samples, and an occasional organism was recovered for 10 days at 35 feet. In the upper stratum, E. Coli failed to appear at 15 feet. The chemical stream could be traced to 85 but not 100 feet.

(c) The effects of clogging in the filtration bed and further restriction of flow from the latrine from increasing sludge and scum mat formation and greater viscosity of the intermediate fluid, was clearly evident within 3 months. The advance of colon organisms was checked and stream regressed. Within 7 months, the bacterial stream had retreated practically to the latrine, and chemical characteristics had diminished.

(d) As the ground water rose to abnormal heights in the spring, septic action was apparent above the packed sludge and a new pollution flow occurred above a portion of the old stream and through sands not previously infiltrated. E. Coli did not advance beyond 10 feet before regression again occurred as the water table fell.

(e) In the early stream, typical E. Coli at first predominated but was shortly accompanied by Cl. welchii which preceded the appearance of E. Coli at distances beyond the initial and were recovered long after the disappearance of the colon organisms during regression. As the stream aged and regressed, atypical E. Coli and other colon forms, typical and atypical, accompanied typical E. Coli or were the only forms recoverable.

(f) At all stages, the intensities of characteristics lessened with distance from the source, the end point blurring gradually into the ground-water. This results from dilution and oxidation of the chemical products and in addition the "filtration" of bacterial organisms. Since the time-temperature function is the prime factor in their death rate, the importance of "defense" is obvious.

(g) Stream characteristics at varying depths were complexly related to velocity and position of strata in relation to latrine conditions. In general the greatest concentration of chemical and bacterial characteristics in the period of significant flow was in the middle stratum, but at 10 feet the bacterial recovery in the bottom stratum approximated that in the middle in the peak period when 50 to 80 colon organisms per cc. were present on pour plates. The E. Coli recovery in the top stratum was less than 1 percent of the lower recovery, but its chemical concentration was somewhat less or more than the lower according to conditions.

2. Oscillation of pollution stream. --As the direction of flow of the ground water varied, the flow from the latrine varied with it, resulting in shifting of the stream back and forth about the source. Therefore wells which at one time yielded gross pollution subsequently yielded slight or no perceptible pollution and vice versa. The effect was to expand the width of the stream due to retention or lag of products in former flow positions. The expansion of the E. Coli stream was transient. The spread of Cl. welchii was more prolonged. The increase in width of the stream is a factor in limiting its lineal extent.

3. Course and width characteristics of the underground stream.

(a) The horizontal shape of the contaminated portion of the stream is similar to a cross-section of a spindle. From the source of contamination, the pollution flow broadens due to the effects of dispersion, soil porosity, and the back-and-forth shifting of the flow. After the greatest breadth of the pollution flow is reached, the shape of the contaminated area converges to zero width.

The chemical dispersion was greater than the bacterial. The maximum width of the chemically polluted area was 5 feet at a distance of 25 feet from the source of pollution, and that of E. Coli was 3 feet at a distance of 15 feet. The anaerobic stream approximated the chemical width.

(b) The intensity of both bacterial and chemical contamination varied from midstream to margins and gradually merged into the normal ground water. The presence of fecal organisms coincided, generally, with the maximum concentration of chemical characteristics. At any vertical cross section of the stream, there were variations in intensity of contamination due to variation of flow thru different strata and to occasional reversals of flow.

4. Pollution under conditions of family use, located in sands over unconsolidated soils:

(a) The findings confirm the observations of others that intestinal organisms are confined to the depository except as they are mechanically transported by other agencies, primarily

fluid flow. Transportation is essentially downward with gravity flow, if soils below be pervious. Transfer by lateral capillarity is normally insignificant, but from pits subject to seepage from rains or to which considerable volumes of water are added regularly, lateral seepage will occur as percolation is retarded and liquids impounded, the area of saturation being domeshaped.

(b) Significant correlation exists between moisture conditions and pollution from deposits of excreta into the subsoil. From a dry latrine (i.e., not receiving fluid other than from excreta) located in an area of high ground water of comparatively rapid flow there was no contamination of test wells located in the path of flow 5 feet from the pit, when the water table in general was 1.5 to 2.0 feet below the pit floor and within 6 inches for a period a month after beginning use. From latrines located on a cliff in an area of comparatively low ground-water investigated by soil borings directly below and laterally colon organisms did not penetrate 1 foot below or 1 foot laterally from the latrine where the pit latrine was dry; colon organisms were carried 3 but not 4 feet below the pit and 1 foot laterally, though not in significant numbers in this instance where the pit latrine was subject to seepage from rains; colon organisms travelled 6 but not 7 feet beneath the pit and approximately 2 feet laterally, though in significant numbers only 1 foot where 100 gallons of water were added daily to the pit latrine.

(c) The limitation of pollution is due to rapid "defense" (clogging of pore spaces of the soil with fine fecal particles and aggregates of colloids and organisms which, in addition to the accumulation of sludge, retards flow and hence increases the time for the death rate of fecal organisms to operate.

Distances to Sources of Contamination: All ground-water sources should be located a safe distance from sources of contamination. In cases where sources are severely limited, however, a ground-water aquifer that might become contaminated may be considered for a water supply if treatment be provided. After a decision has been made to locate a water source in an area, it is necessary to determine the distance the source should be placed from the origin of contamination and the direction of water movement. A determination of a safe distance is based on specific local factors described under title, on "Sanitary Survey".

Because many factors affect a determination of a safe distance between a ground-water supply and a source of contamination, it is impractical to set fixed distances. As a rule, the distance should be the maximum that economics, land ownership, geology, and topography will permit. If at all possible a well should be located on ground that is higher than the source of contamination. Drainage that might reach the source from areas used by livestock should be diverted by ditching.

Each installation should be inspected by a person with sufficient training and experience to evaluate all of the factors involved. Because some guide is needed when qualified individuals are not available, a table of minimum distances is given below. Under certain conditions these minimum recommended distances may be inadequate and will have to be modified. Requirements of the State health department concerned should be met.

Table 3. --Distance from source of contamination to individual water supplies and pump suction lines

Source of Contamination	Distance (feet)[1]	Source of Contamination	Distance (feet)[1]
Sewer	50	Subsurface disposal fields	100 [2]
Septic tanks	50	Seepage pits	100
Subsurface pits	50	Cesspools	150
Pasture	100	Barnyard	100
Sewer of cast iron (leaded or mechanical joints)	10	Farm silo	25
		Pumphouse floor drain of cast iron draining to ground surface	2

[1] These distances constitute minimum separation and shall be increased in areas of creviced rock or limestone, or where the direction of movement of the ground water is from sources of contamination toward the well.

[2] When approved by the authority having jurisdiction, and under special soil conditions, this distance may be reduced. However, a minimum separation of not less than 50 feet shall be maintained.

Table 4. --Location of components of sewage-disposal system

Type of system	Water supply line (pressure)	Distance (feet)				
		Stream	Dwelling	Property line	Disposal field	Seepage pits
Building sewer	10	----	----	------	-------	-----
Septic tank	------	----	5	------	-------	-----
Disposal field	------	25	10	10	-------	-----
Seepage pit	------	50	20	10	20	20
Dry well	------	----	10	------	-------	-----
Cesspool[1]	------	50	20	15	15	15

[1] Not recommended as a substitute for a septic tank. To be used only when found necessary and approved by the Administrative Authority.

Simple Tests to Determine Sources of Pollution - Contamination of water with bacteria of the coliform group is an index of possible infection. Sources of pollution and possibly of contamination may often be determined by simple tests. The tests consist in the addition of some chemical substance to the suspected source of pollution and then determining whether the chemical substance reappears in the water supply. For this purpose a large number of substances that may readily be recognized by taste, odor, or appearance may be used, such as coal oil, carbolic acid, fluorescein and common salt. The conclusion must not be drawn that because these soluble materials reappear in the water, microorganisms and dangerous pollution would necessarily find their way through the soil for an equal distance. Soil has filtering powers and when free from fissures is capable of removing large amounts of bacteria and oxidizing much organic matter. However, these methods are of service in indicating the possibility of danger under certain circumstances and are particularly useful in discovering sources of pollution near wells or in limestone.

Development of Ground Water

The type of ground-water development to be undertaken is dependent upon the geological formations and hydrological characteristics of the water-bearing formation. The development of ground water falls into two main categories:

1. Development by wells
   a. Nonartesian or water table

2. Development from springs
   a. Gravity
   b. Artesian

Nonartesian wells are those that penetrate formations in which ground water is found under water-table conditions. Pumping from the well lowers the water table in the vicinity of the well and water moves toward the well under the pressure differences thus artificially created.

Artesian wells are those that penetrate aquifers in which the ground water is found under hydrostatic pressure. Such a condition occurs in an aquifer that is confined beneath an impermeable layer of material at an elevation lower than that of the intake area of the aquifer. The intake areas or recharge areas of confined aquifers are commonly at high-level surface outcrops of the formations. Ground-water flow occurs from high-level outcrop areas to low-level outcrop areas, which are areas of natural discharge. It also flows toward points where water levels are lowered artificially by pumping from wells. When the water level in the well stands

above the top of the aquifer, the well is described as artesian. A well that yields water by artesian pressure at the ground surface is a flowing artesian well.

Gravity springs occur where water percolating laterally through permeable material overlying an impermeable stratum comes to the surface. They also occur where the land surface intersects the water table. This type of spring is particularly sensitive to seasonal fluctuations in ground-water storage and frequently dwindles to a seep or disappears during dry periods. Gravity springs are characteristically low discharge sources, but when properly developed they make satisfactory individual water supply systems.

Artesian springs discharge from artesian aquifers. They may occur where the confining formation over the artesian aquifer is ruptured by a fault or where the aquifer discharges to a lower topographic area. The flow from these springs depends on the difference in recharge and discharge elevations of the aquifer and on the size of the openings transmitting the water. Artesian springs are usually more dependable than gravity springs, but they are particularly sensitive to the pumping of wells developed in the same aquifer. As a consequence, artesian springs may be dried by pumping.

Springs may be further classified by the nature of the passages through which water issues from the source.

Seepage springs are those in which the water seeps out of sand, gravel, or other material that contains many small interstices. The term as used here includes many large springs as well as small ones. Some of the large springs have extensive seepage areas and are usually marked by the presence of abundant vegetation. The water of small seepage springs may be colored or carry an oily scum because of decomposition of organic matter or the presence of iron. Seepage springs may emerge along the top of an impermeable bed, but they occur more commonly where valleys are cut into the zone of saturation of water-bearing deposits. These springs are generally free from harmful bacteria, but they are susceptible to contamination by surface runoff which collects in valleys or depressions.

Tubular springs issue from relatively large channels, such as the solution channels and caverns of limestone, and soluble rocks and smaller channels that occur in glacial drift. They are sometimes referred to as "bold" springs because the water issues freely from one or more large openings. When the water reaches the channels by percolation through sand or other fine-grained material, it is usually free from contamination. When the channels receive surface water directly or receive the indirect effluent of cesspools, privies, or septic tanks, the water must be regarded as unsafe.

Fissure springs issue along bedding, joint, cleavage, or fault planes. Their distinguishing feature is a break in the rocks along which the water passes. Some of these springs discharge uncontaminated water of deep-source origin. A large number of thermal springs are of this type. Fissure springs, however, may discharge water which is contaminated by surface drainage from strata close to the surface.

Development by Wells

When a well is pumped, the level of the water table in the vicinity of the well will be lowered. (See figure 2.) This lowering or "drawdown" causes the water table or artesian pressure surface, depending on the type of aquifer, to take the shape of an inverted cone called a cone of depression. This cone, with the well at the apex, is measured in terms of the difference between the static water level and the pumping level. At increasing distances from the well, the drawdown decreases until the slope of the cone merges with the static water table. The distance from the well at which this occurs is called the radius of influence. The radius of influence is not constant but tends to continuously expand with continued pumping. At a given pumping rate, the shape of the cone of depression depends on the characteristics of the water-bearing formation. Shallow and wide cones will form in highly permeable aquifers composed of coarse sands or gravel. Steeper and narrower cones will form in less permeable aquifers. As the pumping rate increases, the drawdown increases and consequently the slope of the cone

steepens. The limiting value of the cone depends upon the characteristics of the aquifer.

The character of the aquifer--artesian or water table -- and the physical characteristics of the formation which will affect the shape of the cone include thickness, lateral extent, and the size and grading of sands or gravel. In a material of low permeability such as fine sand or sandy clay, the drawdown will be greater and the radius of influence less than for the same pumpage from very coarse gravel.

For example, when other conditions are equal for two wells, it may be expected that pumping costs for the same pumping rate will be higher for the well surrounded by material of lower permeability because of the greater drawdown.

When the cones of depression overlap, the local water table will be lowered. This requires additional pumping lifts to obtain water from the interior portion of the group of wells. In addition, a wider distribution of the wells over the ground-water basin will reduce the cost of pumping and will allow the development of a larger quantity of water.

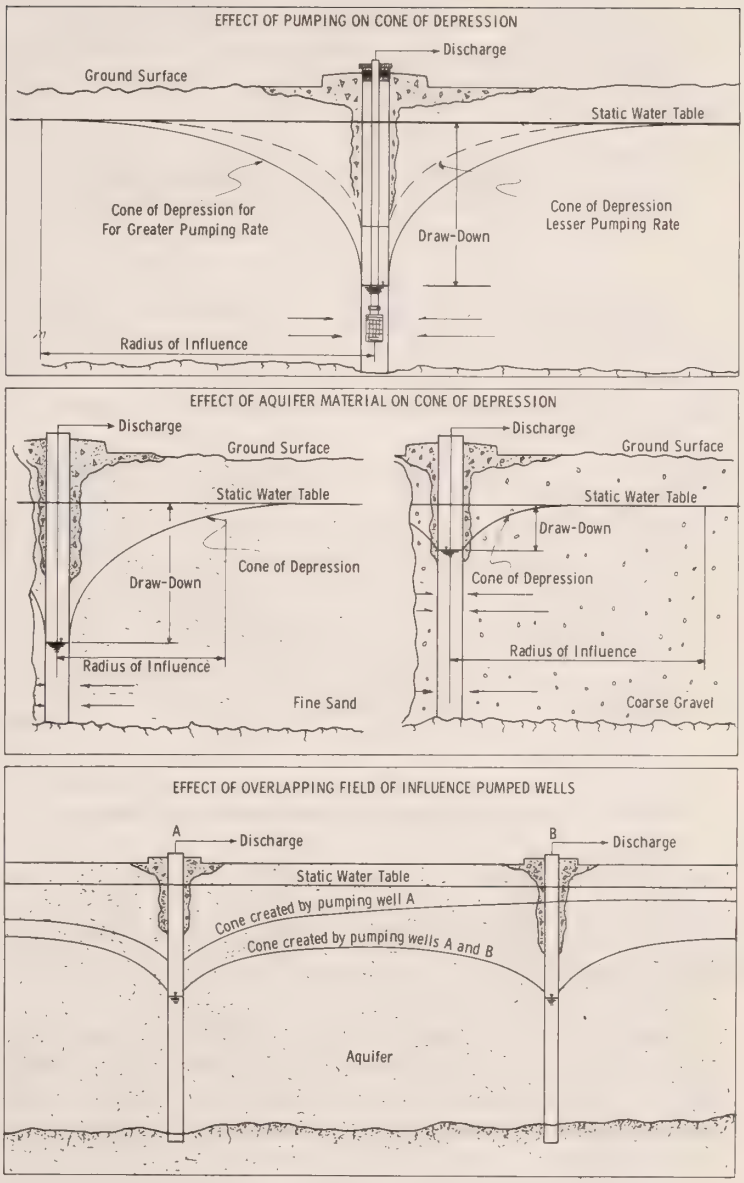


Figure 2. Pumping Effects on Aquifers.

Yield of Various Types of Wells

The amount of water that can be obtained from any type of well depends on three main factors: character of the aquifer, type and construction of the well, and characteristics of the pumping equipment.

The short-term yield of a well depends mainly upon the capacity of the pump, whereas the long-term yield depends primarily upon the characteristics of the aquifer.

The diameter of a well pipe will affect the drawdown and the effective pumping rate. An increase in the diameter of the well pipe will decrease the drawdown and allow an increased pumping rate. The effect of well diameter upon discharge is important in wells with a small diameter. There is a limiting value for the diameter of the well beyond which it is not economically practicable to make it larger.

It is not always possible to accurately predict the yield of a given well. Knowledge can be gained, however, from studying the geology of the area and interpreting the results obtained from other wells constructed in the vicinity. This information will be helpful in selecting the location and type of well most likely to be successful. The information can also provide an indication of the quantity or yield to expect.

A common way to describe the yield of a well is to express its discharge capacity in relation to its drawdown. This relationship is called the specific capacity of the well and is expressed in "gallons per minute (gpm) per foot of drawdown." The specific capacity may range from less than 1 gpm per foot of drawdown for a poorly developed well or one in a tight aquifer to more than 100 gpm per foot of drawdown for a properly developed well in a highly permeable aquifer.

Table 5. -- Characteristics of various types of wells[1]

Characteristics	Type of Well					
	Dug	Bored	Driven	Drilled		Jetted
				Percussion	Rotary	
Range of practical depths (general order of magnitude)	0–50 feet	0–100 feet	0–50 feet	0–1000 feet	0–1000 feet	0–100 feet
Diameter	3–20 feet	2–30 inches	1¼–2 inches	4–18 inches	4–24 inches	4–12 inches
Type of geologic formation:						
Clay	Yes	Yes	Yes	Yes	Yes	Yes
Silt	Yes	Yes	Yes	Yes	Yes	Yes
Sand	Yes	Yes	Yes	Yes	Yes	Yes
Gravel	Yes	Yes	Fine	Yes	Yes	¼" pea gravel
Cemented gravel	Yes	No	No	Yes	Yes	No
Boulders	Yes	Less than well diameter.	No	(In firm bedding)	(Difficult)	No
Sandstone	Soft	Soft	Thin layers	Yes	Yes	No
Limestone	Soft, fractured	Soft, fractured	No	Yes	Yes	No
Dense igneous rock	No	No	No	Yes	Yes	No

[1] The ranges of values in this table are based upon general conditions which may be exceeded for specific areas or conditions.

Wells may be classified according to construction methods, such as dug, bored, driven, drilled, and jetted.

A properly constructed well should exclude surface water from a ground-water source to the same degree as does the undisturbed overlying geologic formation. The well site should not be subject to flooding and should be graded to facilitate the rapid drainage of surface water. The following precautions will insure reasonable protection against entry of surface water.

1. The grade should be sloped away from the well to divert surface water. The area should be filled, if necessary, graded, and maintained to prevent the accumulation or retention of surface water within 50 feet of the well in all directions. The fill may be protected from erosion by riprap or sod where necessary. For a well on a hillside, adequate intercepting ditches should be constructed on the uphill side of the well to keep runoff at least 50 feet away from it in all directions. These ditches should have the capacity to carry the runoff of heavy storms and should be properly maintained.

2. Pump platforms, pumproom floors, or well covers should be located not less than 2 feet above the highest known high-water level of any nearby body of water. The area around the well should be filled and graded to the necessary height.

Table 5 gives general information on the practicality of penetrating various types of geologic formations by the methods indicated.

Dug wells can be sunk only a few feet below the water table. This seriously limits the yield of the well. A dug well that taps a highly permeable formation such as gravel may yield 10 to 30 gpm or even more in some situations with only 2 or 3 feet of drawdown. If the formation is primarily fine sand, the yield may be on the order of 2 to 10 gpm. These refer to dug wells of the sizes commonly used.

Bored wells, like dug wells, can also be sunk only a small depth below the static water level. A penetration of 5 to 10 feet into the water-bearing formation can probably be achieved. If the well is nonartesian, the available drawdown would be 2 or 3 feet less than the depth of water standing in the well. If the well taps an artesian aquifer, however, the static water level will rise to some point above the top of the aquifer. This rise of the static water level increases the depth of the water. The available drawdown and the yield of the well will therefore be increased. A bored well tapping a highly permeable aquifer and providing several feet of available drawdown may yield 20 gpm or more. If the aquifer has a low permeability or the depth of water in the well is small, the yield may be much lower.

Driven wells can be sunk to as much as 30 feet or more below the static water level. A well at this depth can provide 20 feet or more of drawdown when being pumped. The small diameter of the well, however, limits the type of pump that can be employed, so that the yield under favorable conditions is limited to about 30 gpm. In fine sand or sandy clay formations of limited thickness, the yield may be less than 5 gpm.

Drilled and jetted wells can usually be sunk to such depths that the depth of water standing in the well and consequently the available drawdown will vary from less than 10 to hundreds of feet. In productive formations of considerable thickness, yields of 300 gpm and more are readily attained. Drilled wells can be constructed in all instances where driven wells are used and in many areas where dug and bored wells are constructed. The larger diameter of a drilled well as opposed to that of a driven well permits use of larger pumping equipment that can develop the full capacity of the aquifer. As has already been pointed out, the capacity or yield of a well varies greatly, depending upon the permeability and thickness of the formation and upon the available drawdown in the well.

Construction of Wells

Dug wells may be lined with brick, stone, or concrete, depending on the availability of materials and the cost of labor. Precast concrete pipe, available in a wide range of sizes, provides an excellent lining. This lining can be used as a crib as the pit is deepened. When the lining is to be used as a crib, concrete pipe with tongue-and-groove joints and smooth exterior surface is preferred. (See figure 3.) Bell and spigot pipe may be used for a lining where it can be placed inside the crib or in an unsupported pit. This type of pipe requires careful backfilling to guarantee a tight well near the surface. The prime factor with regard to preventing contaminated water from entering a dug well is the sealing of the well lining and otherwise excluding draining-in of surface water at and near the well.

Most dug wells do not penetrate much below the water table because of the difficulties in manual excavation and the positioning of cribs and linings. The depth of excavation can be increased by the use of pumps to lower the water level during construction. Because of their shallow penetration into the zone of saturation, many dug wells fail in times of drought when the water level recedes or when large quantities of water are pumped from the wells.

Because they are difficult to maintain in a sanitary condition, dug wells are not recommended when other ground-water sources can be developed. However, they can furnish a useful supply of water in areas remote from sources of contamination. They are usually excavated with pick and shovel. A power-operated clam shell or orange peel bucket may be used in holes greater than 3 feet in diameter where the material is principally gravel or sand. In dense clays or cemented materials, pneumatic hand tools are effective means of excavation.

To prevent the native material from caving, a crib or lining can be placed in the excavation and moved downward as the pit is deepened. The space between the lining and the undisturbed embankment should be backfilled with clean material. In the region of water-bearing formations, the back filled material should be sand or gravel. Cement grout should be placed to depth of 10 feet below the ground surface to prevent entrance of surface water along the well lining. (See fig. 3)

Due to the difficulty of keeping out contamination from dug wells when the walls are not made

of seamless watertight pipe, another method may be used described below as the Ranney Water Collector.

Ranney Water Collector. The latter disadvantage is removed in the Ranney water collector (See Fig. 4.) A Ranney Collector is, briefly described, a well with horizontally radiating screen pipes. It consists of a cylindrical concrete tank sunk in the ground by the open excavation method. As concrete sections are added at the top, the tank builds up and sinks into the ground. It has a concrete bottom. The lateral screer pipe lines which collect the water consist of a screen sections of pipe pushed out horizontally through precast port holes in six to eight foot sections and welded together. Individual screen lines usually have lengths up to 150 feet, although lengths of 250' and 520' have been used. Fine sand is removed around the screen so that practically no sand entrainment occurs. Ranney collectors can be installed in all types of water bearing formations. Economically exploitable depths are limited to 200 feet below ground. The major advantage of the Ranney collector is its ability to obtain water through induced infiltration from rivers and lakes, the water being en route relieved of its suspended and colloidal load, including bacteria.

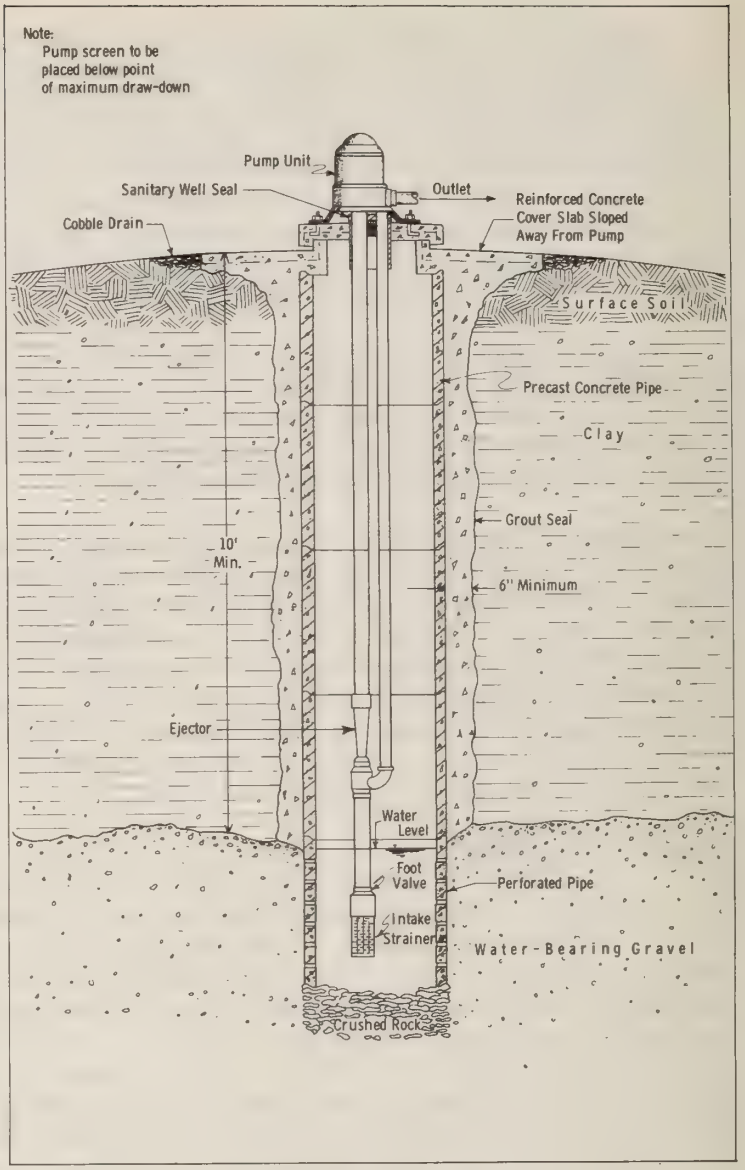


Figure 3. Dug Well.

Bored Wells. Bored wells are commonly constructed with earth augers turned either by hand or by power equipment. Such wells are usually regarded as practical at depths of less than 100 feet when the water requirement is low and the material overlying the water-bearing formation has non-caving properties and contains few large boulders. In suitable material, holes from 2 to 30 inches in diameter can be bored to about 100 feet without caving.

In general, bored wells have the same characteristics as dug wells, but they may be extended deeper into the water-bearing formation.

Bored wells may be cased with vitrified tile, concrete pipe, standard wrought iron, steel casing, or other suitable material capable of sustaining imposed loads. The well may be completed by installing well screens or perforated casing in the water-bearing sand and gravel. Proper protection from

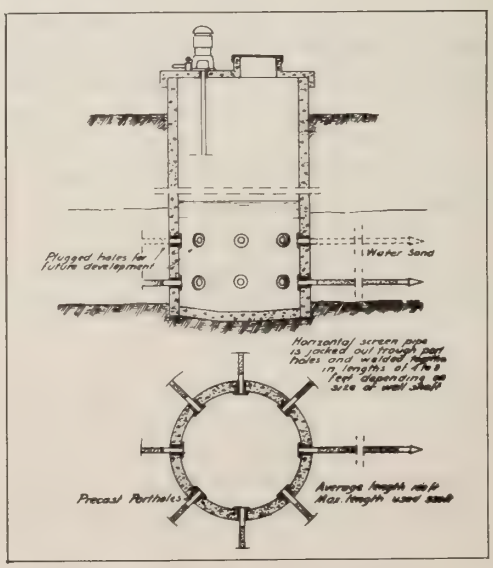


Fig. 4 Diagrammatic Sketch of Ranney Well

surface drainage should be provided by sealing the casing with cement grout to a depth of at least 10 feet below the ground surface.

Driven Wells. The simplest and least expensive of all well types is the driven well. It is constructed by driving into the ground a drive well point which is fitted to the end of a series of pipe section. (See figure 5.) The drive point is of forged or cast steel. Drive points are usually 1-1/4 or 2 inches in diameter. The well is driven with the aid of a maul, a drive shoe, or a pile driver. For deeper wells, the well points are sometimes driven into water-bearing strata from the bottom of a bored or dug well. (See figure 5.) The yield of driven wells is generally small to moderate. Where they can be driven an appreciable depth below the water table, they are no more likely than bored wells to be seriously affected by water-table fluctuations. The most suitable locations for driven wells are areas containing alluvial deposits of high permeability. The presence of coarse gravels, cobbles, or boulders interferes with sinking the well point and may damage the wire mesh jacket.

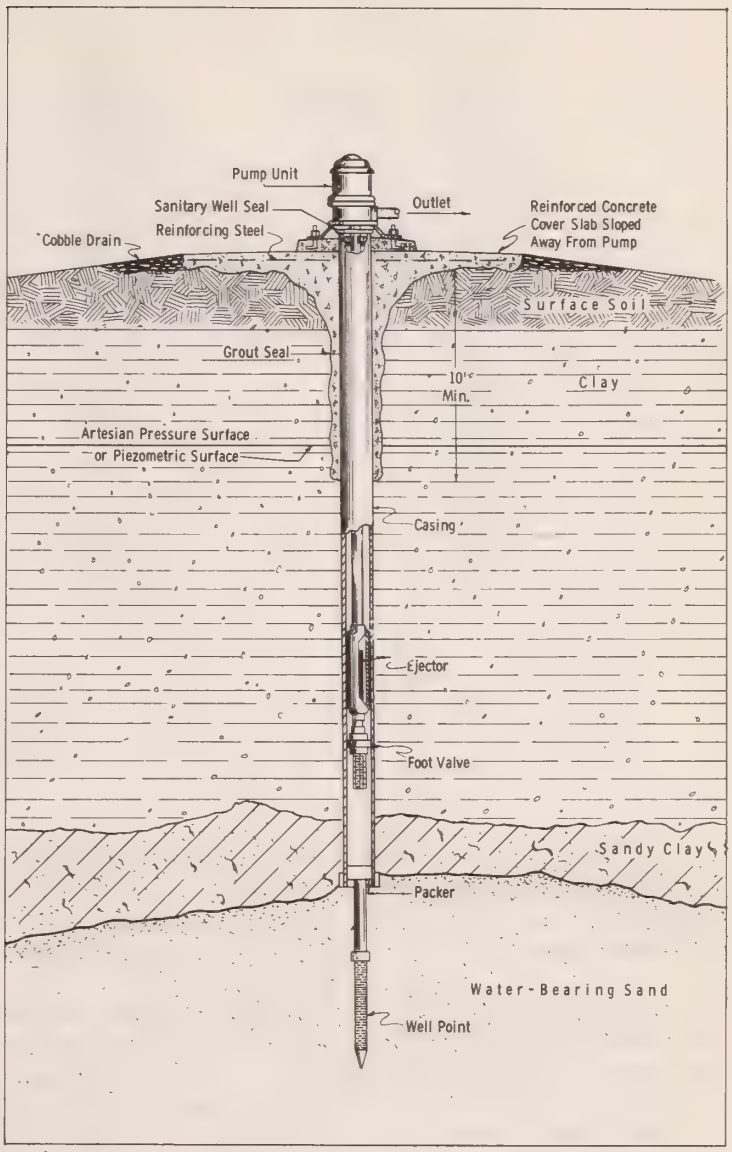


Figure 5. Bored Well with Driven Well Point.

When a well is driven, it is desirable to prepare a pilot hole that extends to the maximum practical depth. This can be done with a hand auger slightly larger than the well point. After the pilot hole has been prepared, the assembled point and pipe are lowered into the hole. Depending on the resistance afforded by the formation, driving is accomplished in several ways. The pipe is driven by directly striking the drive cap, which is snugly threaded to the top of the protruding section of the pipe. A maul, a sledge, or a special driver may consist of a weight and sleeve arrangement which slides over the drive cap as the weight is lifted and dropped in the driving process. (See fig. 6.)

Jetted Wells. A rapid and efficient method of sinking well points is that of jetting or washing-in. This method requires a source of water and a pressure pump. Water forced under pressure down the riser pipe issues from a special washing point. The well point and pipe are then pushed down as material is loosened by the jetting.

The riser pipe of a jetted well is usually used as the suction pipe for the pump. In such instances, surface water may be drawn into the well if the drive pipe develops holes by corrosion. An outside protective casing may be installed to a depth of at least 10 feet to provide protection against the possible entry of contaminated surface water. The annular space between the casings should then be filled with cement grout. The protective casing is best installed in an auger hole and the drive point then driven inside it.

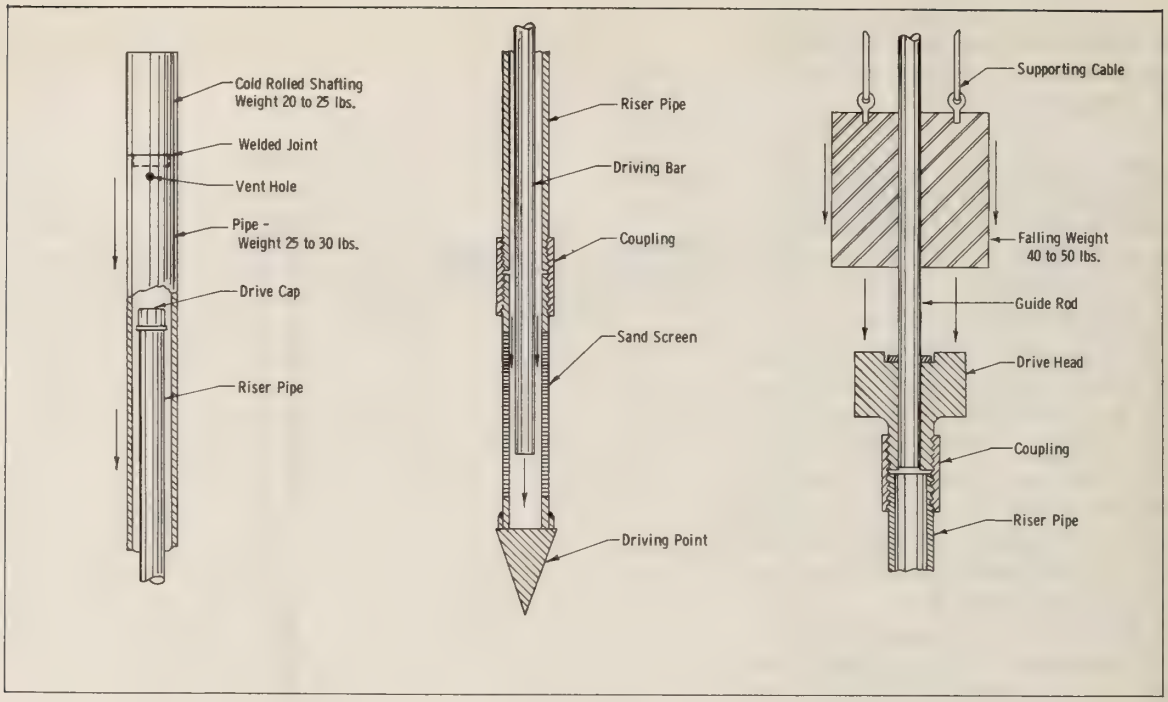


Figure 6. Driving Methods.

Drilled Wells. Construction of a drilled well (see figure 7) is ordinarily accomplished by one of two techniques -- percussion or rotary hydraulic drilling. The selection of the method depends on the geology of the site; the depth, desired diameter, and capacity of the well; and on the investment and time available for construction.

Percussion (Cable Tool) Method. Drilling by the cable-tool or percussion method is accomplished by raising and dropping a heavy drill bit and stem. The impact of the bit crushes and dislodges pieces of the formation. The reciprocating motion of the drill tool mixes the drill cuttings with water into a slurry at the bottom of the hole. This is periodically brought to the surface with a bailer, a 10 to 20 foot long pipe equipped with a valve at the lower end.

Caving is prevented as drilling progresses by driving or sinking into the ground a casing slightly larger in diameter than the bit. When wells are drilled in hard rock, casing is usually necessary only through the overburden of unconsolidated material. A casing may be necessary in hard rock formations to prevent caving of beds of softer material.

Under ordinary conditions it is not difficult to detect water-bearing beds in cable-tool holes, since the slurry in the hole does not tend to seal off the water-bearing formation. A sudden rise or fall in the water level in the hole during bailing indicates that a permeable bed has been entered. Crevices or soft streaks in hard formations are often water-bearing. Sand, gravel, limestone, and sandstone are generally permeable and produce the largest water yields.

Rotary Hydraulic Drilling Method. The rotary hydraulic drilling method may be used in most formations. The essential parts of the drilling assembly include a derrick and hoist, a revolving table through which the drill pipe passes, a series of drill pipe sections, a cutting bit at the lower end of the drill pipe, a pump for circulation of drilling fluid, and a power source to drive the drill.

In the drilling operation, the bit breaks up the material as it rotates and advances. The drilling fluid (called mud) pumped down the drill pipe picks up the drill cuttings and carries them up the annular space between the rotating pipe and the wall of the hole. The mixture of mud and cuttings is discharged to a settling pit where the cuttings drop to the bottom and mud is recirculated to the drill pipe.

When the hole is completed, the drill pipe is withdrawn and the casing placed. The drilling mud is usually left in place and pumped out after the casing and screen are positioned. The annular space between the hole wall and the casing is generally filled with cement grout in non-water-bearing sections but may be enlarged and filled with gravel at the level of water-bearing strata.

When little is known concerning the geology of the area, the search for water-bearing formations must be done carefully and deliberately so that all possible formations are located and tested. Water-bearing formations may be difficult to recognize by the rotary method or may be plugged by the pressure of the mud.

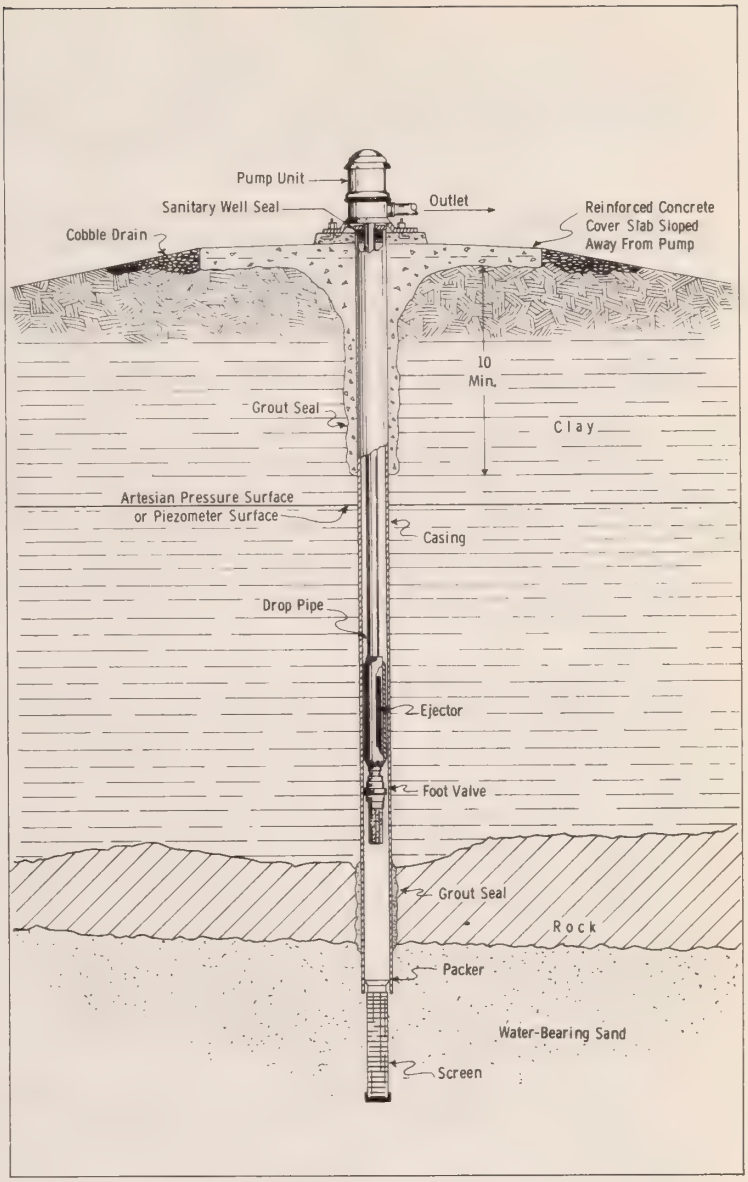


Figure 7. Drilled Well.

Setting Screens or Slotted Casings in Wells. Screens or slotted casings are installed in wells to permit sand-free water to flow into the well and to provide support for unstable formations to prevent caving. The size of the slot for the screen or perforated pipe should be based on a mechanical analysis of carefully selected samples of the water-bearing formation that is to be developed. The analysis is usually made by the screen manufacturer. If the slot size is too large, the well may yield sand when pumped. If the slots are too small, they may become plugged with fine material and the well yield will be reduced. In a drilled well, the screens are normally placed after the casing has been installed; however, in a driven well, the screen is a part of the drive assembly and is sunk to its final position as the well is driven. Methods of screen installation in drilled wells include (1) the pull-back method, (2) the open-hole method, and (3) the bail-down method. The pull-back method of installation is one in which the casing is drawn back to expose a well screen placed inside the casing at the bottom of the well. In the open-hole installation the screen attached to the casing is inserted in the uncased bottom part of the hole when the aquifer portion of the hole remains open. When the bail-down method is employed, the screen is placed at the bottom of the cased hole and advanced into the water-bearing formation by bailing the sand out from below the screen.

The pull-back method is suited to bored or drilled wells, as long as the casing can be moved, while the open-hole method is used in some instances with rotary drilling. The bail-down method may be used in wells drilled by any method where water-bearing formations consist of sand. It is not well adapted to gravel formations.

A screen may not be required in wells tapping bedrock or tightly cemented sediments such as sandstone or limestone.

A fourth method, adaptable primarily in rotary drilled holes, is the wash-down method. This procedure entails the circulation of water, by use of the mud pump, through a special self-closing bottom upward around the screen and through the annular space between the washpipe and the permanent casing to the surface. As material is washed by jet action from below it, the well screen settles to its desired position.

If the screen be placed after positioning of the casing, it must be firmly sealed to the casing. This is generally done by swaging out a lead packer attached to the top of the screen. When the pull-back method of installation is employed, a closed bail bottom usually provides the bottom closure; a self-closing bottom serves this purpose when the wash-down method is used. A special plug is placed in the bottom when the bail-down method is employed. A quantity of lead wool or a small bag of dry cement may also be tamped into the bottom of the screen to seal it.

Development of Wells. Before a well is put into use, it is necessary to completely remove the silt and sand from the formation adjacent to the well screen by one of several processes known as "development". The development procedure unplugs the formation and produces a natural filter of coarser and more uniform particles of high permeability surrounding the well screen. After the development is completed, there will be a well-graded, stabilized layer of coarse material which will entirely surround the well screen and facilitate the flow of water in the formation into the well.

The simplest method of well development is that of surging. In this process the silt and sand grains are agitated by a series of rapid reversals in the direction of flow of water and are drawn toward the screen through larger pore openings. A well may be surged by moving a plunger up and down in it. This action moves the water alternately into and out of the formation. When water containing fine granular material moves into the well, the particles tend to settle to the bottom of the screen. They can be removed subsequently by pumping or bailing.

Other methods of development are interrupted pumping, compressed air, dry ice, and sometimes in consolidated material, explosives when used only by experts. The method of development must be suited to the aquifer and the type of well construction. Proper development is necessary in many formations and under many conditions for the completion of a successful well. Its importance should not be overlooked.

Testing Well for Yield and Drawdown. In order that the most suitable pumping equipment can be selected, a pumping test should be made after the well has been developed to determine its yield and drawdown. The pumping test for yield and drawdown should include the determination of the volume of water pumped per minute or hour, the depth to the pumping level as determined over a period of time at one or more constant rates of pumpage, the recovery of the water level after pumping is stopped, and the length of time the well is pumped at each rate during the test procedure. When the completed well is tested for yield and drawdown, it is essential that it be done accurately by the use of approved measuring devices and accepted methods. Additional information regarding the testing of wells for drawdown or yield may be obtained from the U. S. Geological Survey, the State or local health department, and the manufacturers of well screens or pumping equipment.

Over a period of time, wells may fail to produce for any of these main causes.

1. Failure or wear of the pump.
2. Declining water levels.
3. Plugged or corroded screens.

Proper analysis of the cause necessitates measuring the water level before, during, and after pumping. To facilitate measuring the water level, one should provide for the entrance of a tape or an electrical measuring device into the well in the annular space between the well casing and the pump columns. This can be accomplished by a 1/2- or 3/4- inch threaded hole in the top of the sanitary well seal. A threaded plug should be left in the hole after the yield and drawdown of the well are measured. The plugged hole provides suitable protection against the entrance of any pollution.

Sanitary Protection of Wells

The penetration of a water-bearing formation by a well provides a direct route for possible contamination of the ground water. Although there are different types of wells and well construction, there are basic sanitary aspects which must be considered and followed.

1. The annular space outside the casing should be filled with a watertight cement grout or clays with similar sealing properties from the surface to a minimum of 10 feet below the ground surface. The casing should be surrounded at the ground surface by a 4" concrete slab extending at least 2 feet in all directions.

2. For artesian aquifers, the casing should be sealed into the overlying impermeable formations so as to retain the artesian pressure.

3. When a water-bearing formation containing water of poor quality is penetrated, the formation should be sealed off to prevent the infiltration of water into the well and developed aquifer.

4. A sanitary well seal should be installed at the top of the well casing to prevent the entrance of contaminated water or other objectionable material.

For large-diameter wells such as dug wells, it would be difficult to provide a sanitary well seal; consequently, a reinforced concrete slab extending at least 2 feet beyond the sides of the well should be provided to prevent any entrance through the annular space.

Well Covers and Seals. Every well should be provided with an overlapping, watertight cover at the top of the casing or pipesleeve to prevent contaminated water or deleterious material from entering the well. Pump or power units with closed metal bases can be obtained and properly installed to provide a watertight closure.

A sanitary well seal should be provided at the terminal of any well casing. This is particularly important in wells equipped with pumps having an open-type pedestal or base and in wells where the power unit is not placed directly over the well, as in suction and jet pump installations. There are several makes of sanitary well seals consisting of an expanding rubber gasket between metal plates. They are easily installed and removed when well maintenance is necessary. (See Fig. 8.)

If the pump be not installed immediately after well-drilling and placement of the casing, the top of the casing should be closed with a metal cap screwed or tack-welded into place, or covered with a sanitary well seal.

Every cover and pump platform should be watertight and elevated above the adjacent existing or finished ground level. Pumproom floors should drain to outside level. Floor surfaces should be sloped away from the well to facilitate the rapid removal or diversion of surface and waste water. These surfaces should be constructed of reinforced, watertight concrete and sloped from the well casing or sleeve to the outer edge of the slab. The slab or pumproom floor should have a minimum thickness of 4 inches. Pumps should be mounted on a platform or foundation when placed above the top of the well casing. The top of the casing should be set at least 2 feet above flash-flood level.

Disinfection of Wells. (See Chart 1.) All newly constructed and newly repaired wells should be disinfected before using. An effective and economical method of disinfecting wells and appurtenances is that of using calcium hypochlorite containing approximately 70 percent available chlorine. This chemical can be purchased in granular form at some hardware stores, swimming pool equipment supply outlets, or chemical supply houses.

When used in the disinfection of wells, calcium hypochlorite should be added in sufficient amounts to provide a dosage of approximately 50 mg/l of available chlorine in the well water. This concentration is roughly equivalent to a mixture of 1 ounce of dry chemical per 100 gallons

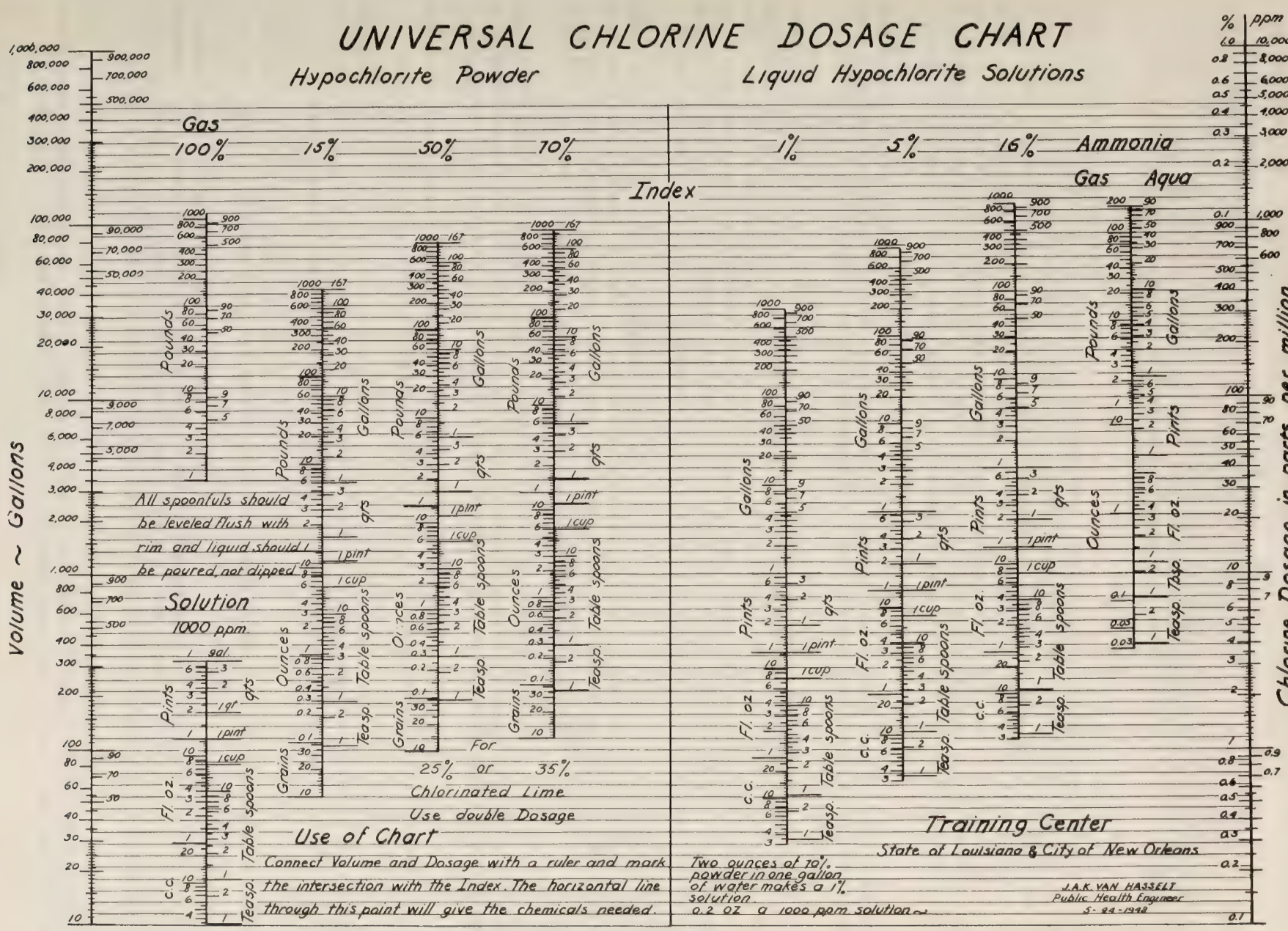

UNIVERSAL CHLORINE DOSAGE CHART
Hypochlorite Powder
Liquid Hypochlorite Solutions
Gas
100%
15%
50%
70%
1%
5%
16%
Ammonia
Gas
Aqua
Index
Volume ~ Gallons
Chlorine Dosage in parts per million
% ppm
Pounds
Ounces
Grains
Gallons
Pints
Fl. oz.
c.c.
qts
1 pint
1 cup
Table spoons
Teasp.
All spoonfuls should be leveled flush with rim and liquid should be poured, not dipped.
Solution
1000 ppm.
For
25% or 35%
Chlorinated Lime
Use double Dosage
Use of Chart
Connect Volume and Dosage with a ruler and mark the intersection with the Index. The horizontal line through this point will give the chemicals needed.
Two ounces of 70% powder in one gallon of water makes a 1% solution.
0.2 oz a 1000 ppm solution ~
Training Center
State of Louisiana & City of New Orleans
J.A.K. VAN HASSELT
Public Health Engineer
5-24-1942

Chart 1.

of water to be disinfected. Practical disinfection requires the use of a stock solution. The stock solution may be prepared by mixing one ounce of high-test hypochlorite with 2 quarts of water. Mixing is facilitated if a small amount of the water is first added to the granular calcium hypochloriate and stirred to a smooth watery paste free of lumps. It should then be mixed with the remaining quantity of water. The stock solution should be stirred thoroughly for 10 to 15 minutes prior to allowing the inert ingredients to settle. The clearer liquid containing the chlorine should be used and the inert material discarded. Each two quarts of stock solution will provide a concentration of approximately 50 mg/l when added to 100 gallons of water. The solution should be prepared in a thoroughly clean utensil; the use of metal containers should be avoided, if possible, as they are corroded by strong chlorine solutions. Crockery, glass, or rubber-lined containers are recommended.

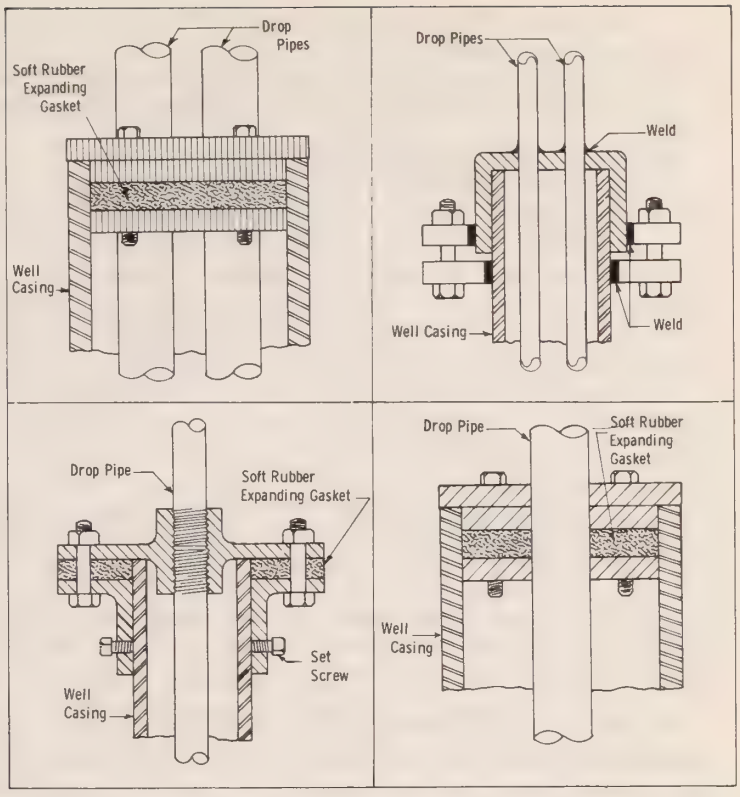


Figure 8. Sanitary Well Seals.

Where small quantities of disinfectant are required and a scale is not available, the material can be measured with a spoon. A heaping tablespoonful of granular calcium hypochlorite weighs approximately 1/2 ounce.

When calcium hypochlorite is not available, other sources of available chlorine such as sodium hypochlorite (12-15% of volume) can be used. Sodium hypochlorite, which is also commonly available as liquid household bleach with 5.25 percent available chlorine, can be diluted with two parts of water to produce the stock solution. Two quarts of this solution can be used for disinfecting 100 gallons of water.

Stock solutions of chlorine in any form will deteriorate rapidly unless properly stored. Dark glass or plastic bottles with airtight caps are recommended. Bottles containing solution should be kept in a cool place and protected from direct sunlight. If proper storage facilities are not available, the solution should always be prepared fresh immediately before use. Commercially available household bleach solutions, because of their convenience and usual reliability as to concentration or strength, are preferred stock solutions for disinfecting individual water supplies.

Dug Wells.

1. After the casing or lining has been completed, follow the procedure outlined below before placing the cover platform over the well.

a. Remove all equipment and materials, including tools, forms, platforms, etc. which will not form a permanent part of the completed structure.

b. Using a stiff broom or brush, wash the interior wall of the casing or lining with a strong solution (100 mg/l of chlorine) to insure thorough cleaning.

2. Place the cover over the well and pour the required amount of chlorine solution into the well through the manhole or pipesleeve opening just before inserting the pump cylinder and drop-pipe assembly. The chlorine solution should be distributed over as much of the surface of the water as possible to obtain proper diffusion of the chemical through the water. Diffusion of the chemical with the well water may be facilitated by running the solution into the well through the water hose or pipeline as the line is being alternately raised and lowered. This method should be followed whenever possible.

3. Wash the exterior surface of the pump cylinder and drop pipe with the chlorine solution as the assembly is being lowered into the well.

4. After the pump has been set in position, pump water from the well until a strong odor of chlorine is noted.
5. Allow the chlorine solution to remain in the well for not less than 24 hours.
6. After 24 hours or more have elapsed, flush the well to remove all traces of chlorine.

Drilled, Driven, and Bored Wells.

1. When the well is being tested for yield, the testpump should be operated until the well water is as clear and as free from tubidity as possible.
2. After the testing equipment has been removed, slowly pour the required amount of chlorine solution into the well just before installing the permanent pumping equipment. Diffusion of the chemical with the well water may be facilitated as previously described.
3. Wash the exterior surface of the pump cylinder and drop pipe with chlorine solution as the assembly is being lowered into the well.
4. After the pump has been set in position, operate the pump until water discharged to waste has a distinct odor of chlorine. Repeat this procedure a few times at 1-hour intervals to insure complete circulation of the chlorine solution through the column of water in the well and the pumping equipment.
5. Allow the chlorine solution to remain in the well for not less than 24 hours.
6. After 24 hours or more have elapsed, flush the well to remove all traces of chlorine. The pump should be operated until water discharged to waste is free from the chlorine odor.

In the case of deep wells having a high-water level, it may be necessary to resort to special methods of introducing the disinfecting agent into the well so as to insure proper diffusion of chlorine throughout the well. The following method is suggested.

Place the granulated calcium hypochlorite in a short section of pipe capped at both ends. A number of small holes should be drilled through each cap or into the sides of the pipe. One of the caps should be fitted with an eye to facilitate attachment of a suitable cable. The disinfecting agent is distributed when the pipe section is lowered or raised throughout the depth of the water.

Flowing Artesian Wells. The water from flowing artesian wells is generally free from contamination as soon as the well is completed or after it has been allowed to flow a short time. It is therefore not generally necessary to disinfect flowing wells. If, however, analyses show persistent contamination, the well should be thoroughly disinfected as follows.

Use a device such as the pipe described in the preceding section or any other appropriate device by means of which a surplus supply of disinfectant can be placed at or near the bottom of the well. The cable supporting the device can be passed through a stuffing box at the top of the well. After the disinfectant has been placed at or near the bottom of the well, throttle down the flow sufficently to obtain an adequate concentration. When water showing an adequate disinfectant concentration appears at the surface, close the valve completely and keep it closed for at least 24 hours.

Chlorine Treatment of Water-Bearing Strata. Sometimes a well is encountered that does not respond to the ususal methods of disinfection. A well like this has usually been contaminated by water that entered under sufficient head to displace water into the water-bearing formation. The displaced water carries contamination with it. The contamination that has been carried into the water-bearing formation can be eliminated or reduced by forcing chlorine into the formation. Chlorine may be introduced in a number of ways, depending on the construction of the well. In some wells it is advisable to chlorinate the water and then add a considerable volume of a chlorine solution in order to force the treated water into the formation. When this procedure is followed, all chlorinated water should have a chlorine strength of approximately 50 mg/l. In other wells, such as the drilled well cased with standard weight casing pipe, it is entirely practicable to chlorinate the water, cap the well, and apply a head of air. When air is alternately applied and released, a vigorous effect is obtained and chlorinated water is forced into the water-bearing formation. In this procedure, the chlorine strength of the treated water in the well will be reduced by dilution as it mixes with the water in the water-bearing formation. It is therefore advisable to double or triple the quantity of chlorine compound to be used so as to have a chlorine strength of 100 to 150 mg/l in the well as the surging process is started. After treating a well in this manner, it is, of course, necessary to flush it to remove the excess chlorine.

Bacteriological Tests Following Disinfection. If the bacteriological examination of water samples collected after disinfection indicates that the water is not safe for use, disinfection should be repeated until tests show that water samples from that portion of the system being disinfected are satisfactory. Samples collected immediately after disinfection may not be representative of the water served normally. Hence, if bacteriological samples are collected immediately after disinfection, it is necessary that the sampling be repeated several days later to check on the delivered water under normal conditions of operation and use. The water from the system should

not be used for domestic and culinary purposes until adequate treatment has been provided.

Abandonment of Wells. Unsealed, abandoned wells constitute a potential hazard to the public health and welfare of the surrounding area. The sealing of an abandoned well presents certain problems, the solution of which involves consideration of the construction of the well and the geological and hydrological conditions of the area. In the proper sealing of a well, the main factors to be considered are elimination of any physical hazard, the prevention of any possible contamination of the ground water, the conservation and maintenance of the yield and hydrostatic pressure of the aquifer, and the prevention of any possible contact between desirable and undesirable waters.

The basic concept behind the proper sealing of any abandoned well is that of restoration, as far as feasible, of the controlling geological conditions that existed before the well was drilled or constructed. If this restoration can be properly accomplished, an abandoned well will not create a physical or health hazard.

When a well is to be permanently abandoned, the lower portion of it is best protected when filled with concrete, cement grout, neat cement or clays with sealing properties similar to those of cement. When dug or bored wells are filled, as much of the lining should be removed as possible so that surface water will not reach the water-bearing strata through a porous lining or one containing cracks or fissures. When any question arises, follow the regulations and recommendations of the State or local health department.

Abandoned wells should N E V E R be used for the disposal of sewage or other wastes.

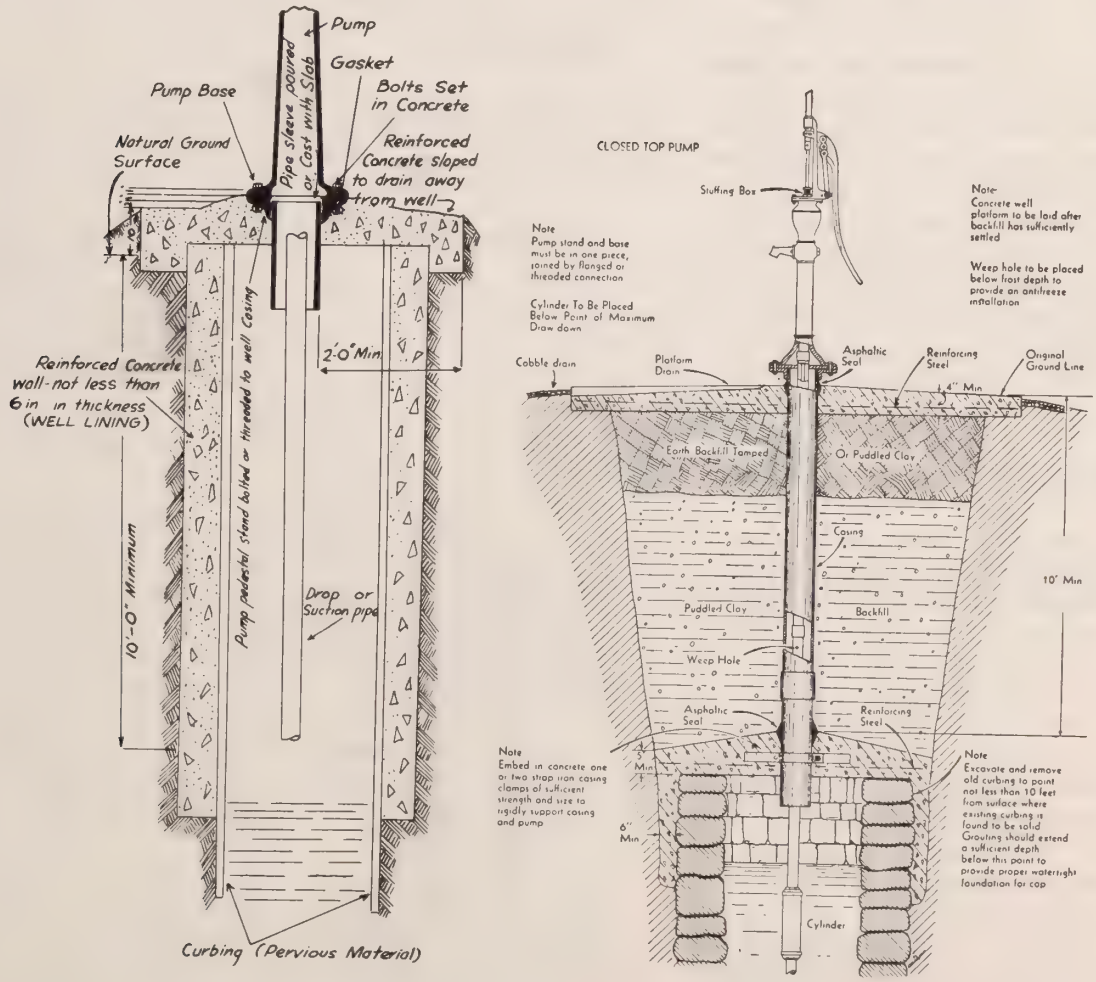

Pump
Gasket
Pump Base
Bolts Set in Concrete
Natural Ground Surface
Pipe sleeve poured or Cast with Slab
Reinforced Concrete sloped to drain away from well
Reinforced Concrete wall-not less than 6 in in thickness (WELL LINING)
2'-0" Min
10'-0" Minimum
Pump pedestal stand bolted or threaded to well Casing
Drop or Suction pipe
Curbing (Pervious Material)
CLOSED TOP PUMP
Stuffing Box
Note
Pump stand and base must be in one piece, joined by flanged or threaded connection
Cylinder To Be Placed Below Point of Maximum Draw down
Note
Concrete well platform to be laid after backfill has sufficiently settled
Weep hole to be placed below frost depth to provide an antifreeze installation
Cobble drain
Platform Drain
Asphaltic Seal
Reinforcing Steel
Original Ground Line
4" Min
Earth Backfill Tamped
Or Puddled Clay
Casing
10' Min
Puddled Clay
Backfill
Weep Hole
Asphaltic Seal
Reinforcing Steel
Note
Embed in concrete one or two strap iron casing clamps of sufficient strength and size to rigidly support casing and pump
6" Min
Note
Excavate and remove old curbing to point not less than 10 feet from surface where existing curbing is found to be solid Grouting should extend a sufficient depth below this point to provide proper watertight foundation for cap
Cylinder

Fig. 9. Plan for Construction or Rebuilding of Dug Wells

Reconstruction of Existing Dug Wells. (figure 9) Existing wells used for domestic water supplies subject to contamination should be reconstructed so as to insure safe water. When reconstruction is not practicable, the water supply should be treated or a new well constructed.

Dug wells with stone or brick casings can often be rebuilt by enclosing existing casings with concrete or by the use of a buried concrete slab.

Care must be exercised on entering wells because until properly ventilated they may contain dangerous gases or lack oxygen. A well should be opened for several hours before anyone enters it. A lighted gasoline or carbine lantern should then be attached to a rope and lowered to the bottom. If the lantern remains lit, it is reasonably safe for one to enter the well. An additional precaution is to fasten a rope to the person entering the well and have one or more attendants on hand to pull him to the surface at the first sign of danger.

Improvements should be planned so that the reconstructed well will conform as nearly as possible with the principles set forth in this manual. If there be any doubt as to what should be done, advice should be obtained from the State or local health department.

Special Considerations in Constructing Artesian Wells. In order that the water may be conserved and the productivity of an artesian well improved, it is essential that the casing be sealed into the confining stratum. Otherwise, a loss of water may occur by leakage into lower pressure permeable strata at higher elevations. A flowing artesian well should be designed so that the movement of water from the aquifer can be controlled. Water can be conserved if the artesian well be equipped with a valve or shut-off device. When the recharge area and aquifer are large and the number of wells which penetrate the aquifer are small, the flowing artesian well produces a fairly steady flow of water throughout the year.

Development of Springs

There are two general requirements necessary in the development of a spring used as a source of domestic water: (1) selection of a spring with adequate capacity to provide the required quantity or quality of water for its intended use throughout the year, (2) protection of the sanitary quality of the spring. The measures taken to develop a spring must be tailored to its geological conditions and sources.

The features of a spring encasement are the following: (1) an open-bottom, watertight basin intercepting the source which extends to

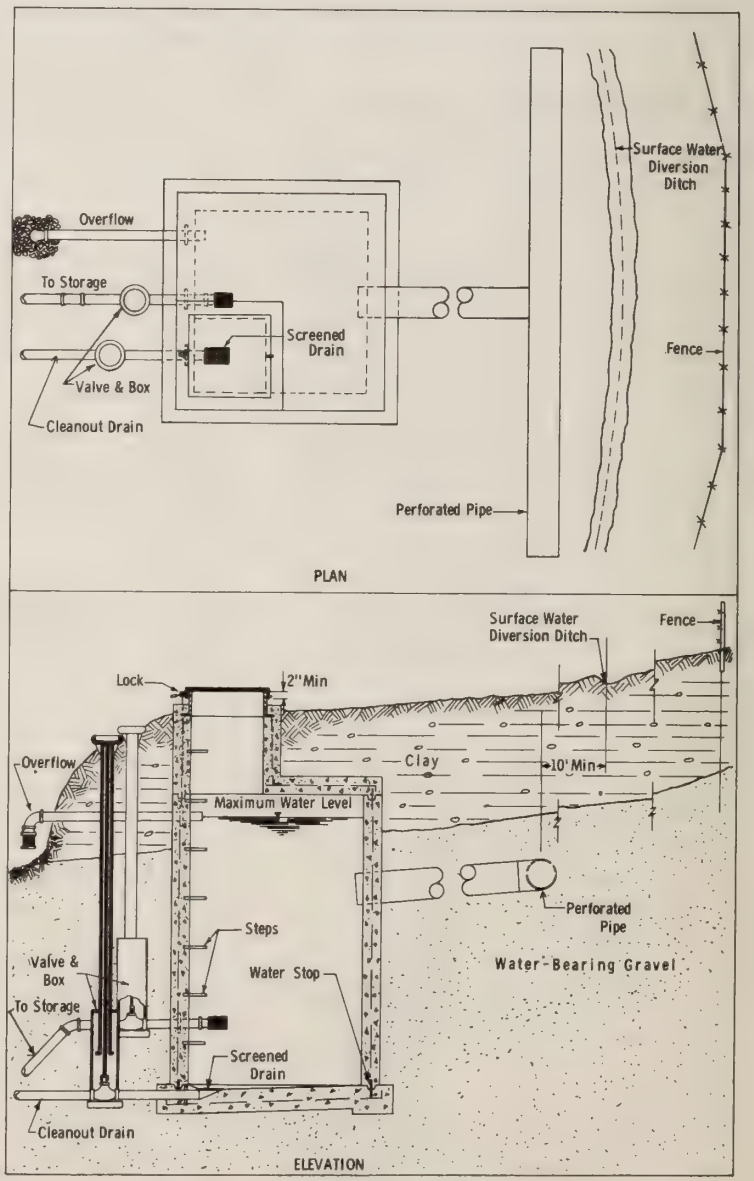


Figure 10. Spring Protection.

bedrock or a system of collection pipes and a storage tank, (2) a cover which prevents the entrance of surface drainage or debris into the storage tank, (3) provision for the cleanout and emptying of the tank contents, (4) provision for overflow, and (5) a connection to the distribution system or auxiliary supply. (See Fig. 10)

A tank is usually constructed in place with reinforced concrete of such dimensions as to enclose or intercept as much of the spring as possible. When a spring is located on a hillside, the downhill wall and sides are extended to bedrock or to a depth that will insure maintenance of an adequate water level in the tank. Supplementary cutoff walls of concrete or impermeable clay extending laterally from the tank may be used to assist in controlling the water table in the locality of the tank. The lower portion of the uphill wall of the tank can be constructed of stone, brick, or other material so placed that water may move freely into the tank from the formation. Backfill of graded gravel and sand will aid in restricting movement of fine material from the formation toward the tank.

The tank cover should be cast-in-place to insure a good fit. Forms should be designed to allow for shrinkage of concrete and expansion of form lumber. The cover should extend down over the top edge of the tank at least 2 inches. The tank cover should be heavy enough so that it cannot be dislodged by children and should be equipped for locking.

A drain pipe with an exterior valve should be placed close to the wall of the tank near the bottom. The pipe should extend horizontally so as to clear the normal ground level at the point of discharge by at least 6 inches. The discharge end of the pipe should be screened to prevent the entrance of rodents and insects.

The overflow is usually placed slightly below the maximum water-level elevation and screened. A drain apron of rock should be provided to prevent soil erosion at the point of overflow discharge.

The supply outlet from the developed spring should be located about 6 inches above the drain outlet and properly screened. Care should be taken in casting pipes into the walls of the tank to insure good bond with the concrete and freedom from honeycomb around the pipes.

Sanitary Protection of Springs. Springs usually become contaminated when barnyards, sewers, septic tanks, cesspools, or other sources of pollution are located on higher adjacent land. In limestone formations, however, contaminated material frequently enters the water-bearing channels through sink holes or other large openings and may be carried along with ground water for long distances. Similarly, if material from such sources of contamination finds access to the tubular channels in glacial drift, this water may retain its contamination for long periods of time and for long distances.

The following precautionary measures will help to insure developed spring water of a consistently high quality.

1. Provide for the removal of surface drainage from the site. A surface drainage ditch located at least 50 feet away on the uphill side of the spring will prevent contaminating material from entering the source.
2. Construct a suitable fence at least 100 feet from the water source to prevent entry of livestock. The drainage ditch should be inside the fence at all points uphill from the source.
3. Provide for access to the tank for maintenance, but prevent removal of the cover by a suitable locking device.
4. Monitor the quality of the spring water with periodic checks for contamination. A marked increase in turbidity after a storm is a good indication that surface runoff is reaching the spring.

Disinfection of Springs. Spring encasements should be disinfected by a procedure similar to that used for dug wells. If the water pressure is not sufficient to raise the water to the top of the encasement, it may be possible to shut off the flow and thus keep the disinfectant in the encasement for 24 hours. If the flow cannot be shut off entirely, arrangements should be made to supply disinfectant continuously for as long a period as practicable.

Infiltration Galleries

Many recreational or other developments located in the mountains have access to water supplies which are usually located near the headwaters of mountain streams where the watersheds are generally heavily forested and uninhabited by man. Under these conditions, contamination is limited to soil bacteria and animal pollution which reaches the streams during and following periods of runoff from the watershed.

Some of the major problems which are encountered in operating and maintaining these supplies are created by debris and turbidity encountered at the waterworks intake following spring thaws and periods of heavy rainfall. When practical, arrangements should be made to remove this material before it reaches the intake. Experience has demonstrated that this material can be removed successfully, especially when small volumes of water are involved, by installing an infiltration gallery at or near the intake.

Where soil formations adjoining a stream are favorable, the water can be intercepted by an infiltration gallery located a reasonable distance from the high-water level and a safe distance below the ground surface. The gallery should be installed so that it will intercept the flow from the stream after flowing through the intervening soil formations between the stream and infiltration gallery.

A typical installation generally involves the construction of an under-drained, sand-filter trench located parallel to the stream bed and about 10 feet from the high-water mark. The sand filter is usually located in a trench with a minimum width of 30 inches and a depth of about 10 feet. At the bottom of the trench, perforated or open joint tile is laid in a bed of gravel about 12 inches in thickness with about 4 inches of graded gravel located over the top of the tile to support the filtering material. The embedded tile is then covered with clean, coarse sand to a minimum depth of 24 inches, and the remainder of the trench backfilled with fairly impervious material. The collection tile is terminated in a watertight, concrete basin from where it is diverted or pumped to the distribution system following chlorination.

Where soil formations adjoining a stream are unfavorable for the location of an infiltration gallery, the debris and turbidity which are occasionally encountered in a mountain stream can be removed by constructing a modified infiltration gallery -- slow sand filter combination in the stream bed. A typical installation involves the construction of a dam across the stream to form a natural pool or the excavation of a pool behind the dam. The filter is installed in the pool behind the dam by laying perforated pipe in a bed of graded gravel which is covered by at least 24 inches of clean, coarse sand. About 24 inches of free board should be allowed between the surface of the sand and the dam spillway. The collection lines usually terminate in a watertight, concrete basin located adjacent to the upstream face of the dam from where the water is diverted to chlorination facilities. Experience with these units indicates that they provide satisfactory service with limited maintenance.

Surface Water for Rural Use

The selection and use of surface water sources for individual water supply systems require consideration of additional factors not usually associated with ground-water sources. When small streams, open ponds, lakes, or open reservoirs must be used as sources of water supply, the danger of contamination and of the consequent spread of enteric diseases such as typhoid fever and dysentery is increased. As a rule, surface water should be used only when ground-water sources are not available or are inadequate. Clear water is not always safe, and the old saying that running water "purifies itself" to drinking water quality within a stated distance is false.

The physical and bacteriological contamination of surface water, except in sparsely settled areas, make it necessary to regard such sources of supply as unsafe for domestic use unless reliable treatment, including filtration and disinfection if necessary, is provided. It should be recognized also that the treatment of surface water to insure a constant, safe supply requires diligent attention to operation and maintenance by the owner of the system.

When ground-water sources are limited, consideration should be given to their development for domestic purposes only. Surface-water sources can then provide water needed for stock and poultry watering, gardening, firefighting, and similar purposes. Treatment of surface water used for livestock is not generally considered essential. There is, however, a trend to provide stock and poultry drinking water which is free from bacterial contamination and certain chemical elements.

Sources of Surface Water. Principal sources of surface water which may be developed include controlled catchments, ponds or lakes, surface streams, and irrigation canals. Except for irrigation canals, where discharges are dependent on irrigation activity, these sources derive water from direct precipitation over the drainage area.

Because of the complexities of the hydrological, geological, and meteorological factors affecting surface-water sources, it is recommended that in planning the development of natural catchment areas of more than a few acres, engineering advice be obtained.

In order to estimate the yield of source, it is necessary for one to consider the following information pertaining to the drainage area.

1. Total annual precipitation
2. Seasonal distribution of precipitation
3. Annual or monthly variations of rainfall from normal levels
4. Annual and monthly evaporation and transpiration rates
5. Soil moisture requirements and infiltration rates
6. Runoff gauge information
7. All available local experience records

Much of the required data, particularly that concerning precipitation, can be obtained from publications of the United States Weather Bureau. Essential data such as soil moisture and evapo-transpiration requirements may be obtained from local soil conservation and agricultural agencies or from field tests conducted by hydrologists.

Controlled Catchments

In some areas ground water is so inaccessible or so highly mineralized that it is not satisfactory for domestic use. In these cases the use of controlled catchments and cisterns may be necessary. A properly located and constructed controlled catchment and cistern, augmented by a satisfactory filtration unit and adequate disinfection facilities, will provide a safe water.

A controlled catchment is a defined surface area on which rainfall runoff is collected. It may be a roof or a paved ground surface. The collected water is stored in a constructed covered tank called a cistern or reservoir. Ground-surface catchments should be fenced to prevent unauthorized entrance by either man or animals. There should be no possibility of the mixture of undesirable surface drainage and controlled runoff. An intercepting drainage ditch around the upper edge of the area and a raised curb around the surface will prevent the entry of any undesirable surface drainage.

For these controlled catchments, simple guide lines to determine water yield from rainfall totals can be established. When the controlled catchment area has a smooth surface or is paved and the runoff is collected in a cistern, water loss due to eveporation, replacement of soil moisture deficit, and infiltration is small. As a general rule, losses from smooth concrete or asphalt-covered ground catchments average less than 10 percent; for shingled roofs or tar and gravel surfaces losses should not exceed 15 percent, and for sheet metal roofs the loss is negligible.

A conservative design can be based on the assumption that the amount of water that can be recovered for use is three-fourths of the total rainfall. (See Fig. 13.)

Location. A controlled catchment may be suitably located on a hillside near the edge of a natural bench. The catchment area can be placed on a moderate slope above the receiving cistern.

The location of the cistern should be governed by both convenience and quality protection. A cistern should be as close to the point of ultimate use as practical. A cistern should not be placed closer than 50 feet from any part of a sewage-disposal installation, and should be on higher ground.

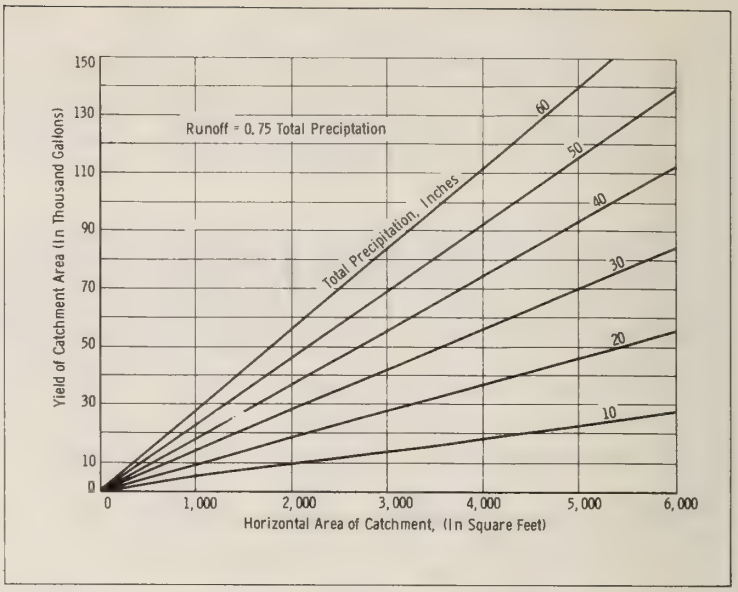


Figure 11. Yield of Impervious Catchment Areas.

Cisterns collecting water from roof surfaces should be located adjacent to the building, but not in basements subject to flooding. They may be placed below the surface of the ground for protection against freezing in cold climates and to keep water temperatures low in warm climates but should be situated on the highest ground practicable, with the surrounding area graded to provide good drainage.

Size. The size of a cistern needed will depend on the size of the family and the length of time between periods of heavy rainfall. Daily water requirements can be estimated from Table 6. The size of the catchment or roof will depend on the amount of rainfall and the character of the surface. It is desirable to allow a safety factor for lower than normal rainfall levels. Designing for two-thirds of the mean annual rainfall will result usually in a catchment area of adequate capacity.

Table 6

DIMENSIONS SUGGESTED FOR INDICATED ROOF AREAS AND ANNUAL RAINFALL OF 30" (ASSUMING TOTAL PRECIPITATION ENTERS THE TANK)

ROOF AREA SQ. FEET	RAW WATER TANK (DEPTH 2'-6")	FILTER (DEPTH 3'-0")	FILTERED WATER TANK (DEPTH 10'-0")	FILTERED WATER TANK STORAGE IN GALS.
400	3'-6" X 9'-9"	3'-6" X 3'-6"	8'-4" X 12'-0"	7,500
600	4'-0" X 12'-9"	4'-0" X 4'-0"	10'-0" X 15'-0"	11,250
800	4'-9" X 14'-6"	4'-9" X 5'-6"	12'-0" X 16'-9"	15,075
1000	4'-9" X 17'-9"	4'-9" X 6'-0"	12'-6" X 20'-0"	18,750
1200	6'-0" X 17'-9"	6'-0" X 6'-0"	15'-0" X 20'-0"	22,500

The above example illustrates the procedure for determining the size of the cistern and required catchment area. Assume that the minimum drinking and culinary requirements of a family of four persons are 100 gallons per day[1] (4 persons x 25 gallons per day = 100 gallons)

[1]Twenty-five gallons per person per day, assuming that other uses are supplied by water of poorer quality.

and that the effective period [2] between rainy periods is 150 days. The volume of the cistern required will be 15,000 gallons (100x150). This volume could be held by a cistern 10 feet deep and 15 feet square. If the annual rainfall is 50 inches, then the total design rainfall is 13.7 inches (50x2/3x150/365). In figure 11 the required catchment area is 2600 square feet.

Construction. Cisterns should be of watertight construction with smooth interior surfaces. Manhole or other covers should be tight to prevent the entrance of light, dust, surface water, insects, and animals.

Manhole openings should have a watertight curb with edges projecting a minimum of 4 inches above the level of the surrounding surface. The edges of the manhole cover should overlap the curb and project downward a minimum of 2 inches. The covers should be provided with locks to minimize the danger of contamination and accidents.

Provision can be made for diverting initial runoff from paved surfaces or roof tops before the runoff is allowed to enter the cistern (Figure 12).

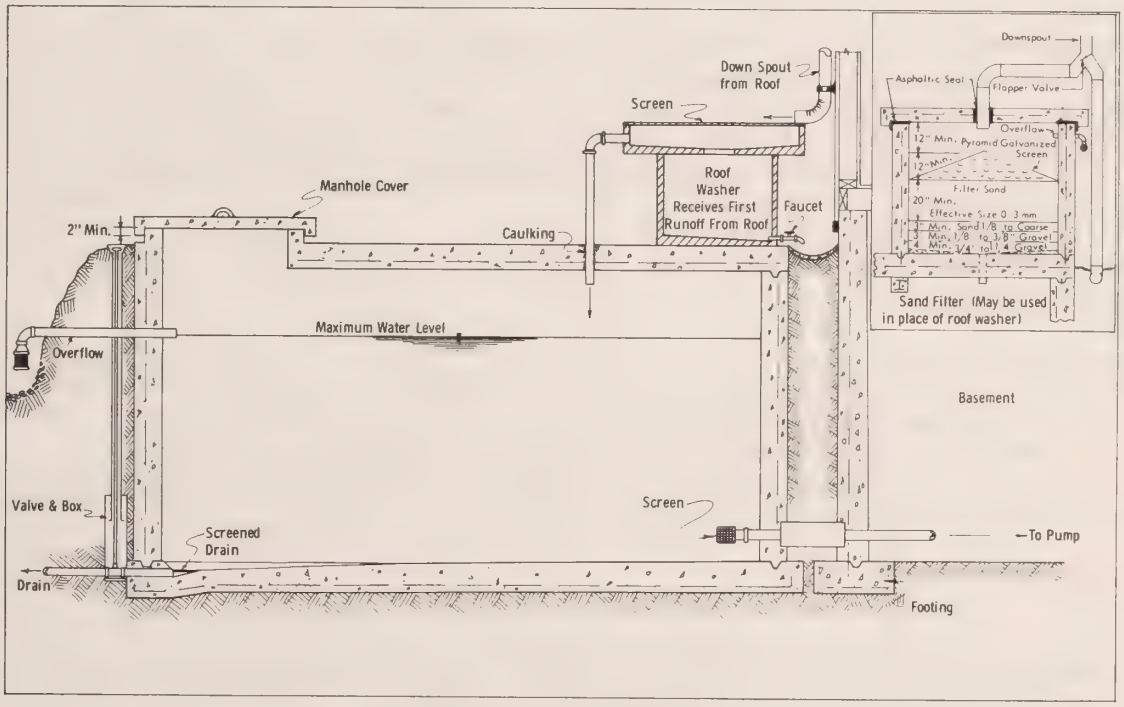


Figure 12. Cistern.

Inlet, outlet, and waste pipes should be effectively screened. Cistern drains and waste or sewer lines should not be connected.

Underground cisterns can be built of brick or stone, although reinforced concrete is preferable. If used, brick or stone must be low in permeability and laid with full Portland cement mortar joints. Bricks should be wet before laying. High quality workmanship is required, and the use of unskilled labor for laying brick or stone is not advisable. Two 1/2-inch plaster coats of 1:3 Portland cement mortar on the interior surface will aid in providing waterproofing. A hard impervious surface can be made by troweling the final coat before it is fully hardened.

Figure 12 shows a suggested design for a cistern of reinforced concrete. A dense concrete should be used to obtain watertightness and should be vibrated adequately during

[2] Effective period is the number of days between periods of rainfall during which there is negligible precipitation.

construction to eliminate honeycomb. All masonary cisterns should be allowed to wet cure properly before being used.

The procedures outlined in this chapter under Disinfection of Water-Distribution System should be followed in disinfecting the cistern with chlorine solutions. Initial and periodic water samples should be taken to determine the bacteriological quality of the water supply. Chlorination may be required on a continuing basis if the bacteriological results indicate that the quality is unsatisfactory.

Ponds or Lakes

A pond or lake should be considered as a source of water supply only after ground-water sources and controlled catchment systems are found to be inadequate or unacceptable. The development of a pond as a supply source depends on several factors: (1) the selection of a watershed that permits only water of the highest quality to enter the pond, (2) usage of the best water collected in the pond, (3)filtration of the water to remove turbidity and reduce bacteria, (4) disinfection of filtered water, (5) proper storage of the treated water, and (6) proper maintenance of the entire water system. Local authorities may be able to furnish advice on pond development.

The value of a pond or lake development is its ability to store water during wet periods for use during periods of little or no rainfall. A pond should be capable of storing a minimum of one year's supply of water. It must be of sufficient capacity to meet water supply demands during periods of low rainfall with an additional allowance for seepage and evaporation losses. The drainage area (watershed) should be large enough to catch sufficient water to fill the pond or lake during wet seasons of the year.

Careful consideration of the location of the watershed and pond site reduces the possibility of chance contamination.

The watershed should:

1. Be clean, preferably grassed.
2. Be free from barns, septic tanks, privies, and soil-absorption fields.
3. Be effectively protected against erosion and drainage from livestock areas.
4. Be fenced to exclude livestock.

The pond should:

1. Be not less than 8 feet deep at deepest point.
2. Be designed to have the maximum possible water storage area over 3 feet in depth.
3. Be large enough to store at least one year's supply.
4. Be fenced to keep out livestock.
5. Be kept free of weeds, algae, and floating debris.

In many instances pond development requires the construction of an embankment with an overflow or spillway. Assistance in designing a storage pond may be available from Federal, State, or local health agencies; the U.S. Soil Conservation Service; and in publications from the State or county agricultural, geological, or soil conservation departments. For specific conditions, engineering or geological advice may be needed.

Intake: A pond intake must be properly located in order that it may draw water of the highest possible quality. When the intake is placed too close to the pond bottom, it may draw turbid water or water containing decayed organic material. When placed too near the pond surface, the intake system may draw floating debris, algae, and aquatic plants. The depth at which it operates best will vary, depending upon the season of the year and the layout of the pond. The most desirable water is usually obtained when the intake is located between 12 and 18 inches below the water surface. An intake located at the deepest point of the pond makes maximum use of stored water.

Pond intakes should be of the type illustrated in figure 11. This is known as a

floating intake. The intake consists of a flexible pipe attached to a rigid conduit which passes through the pond embankment.

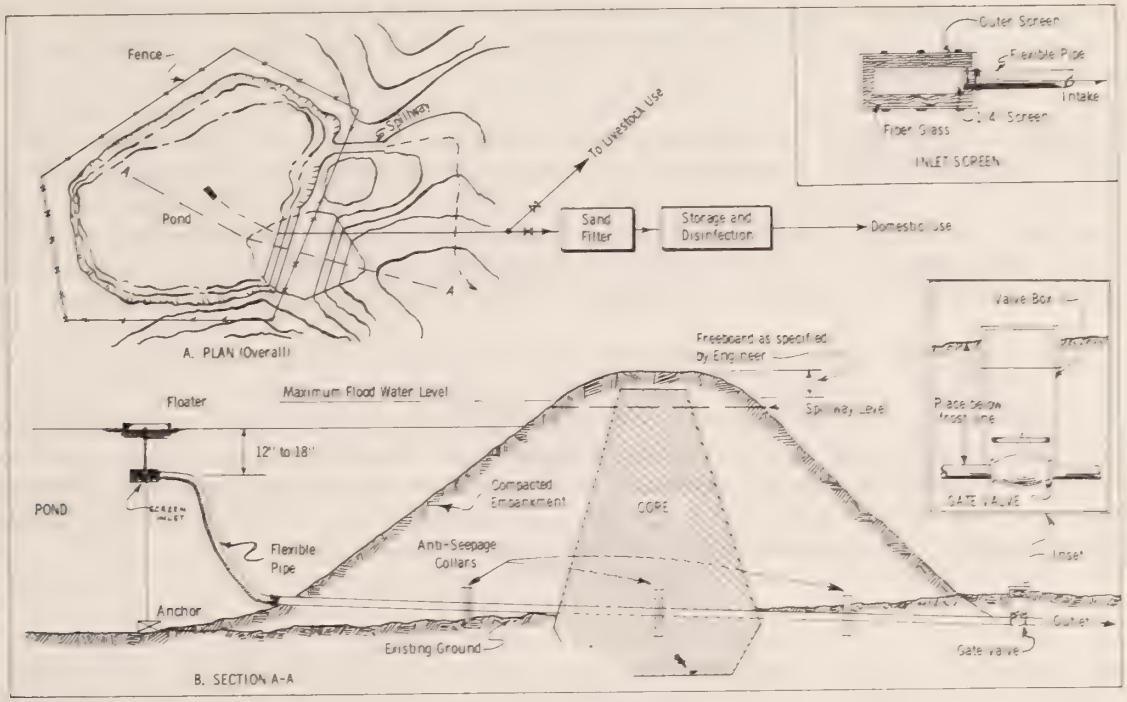


Figure 13. Pond

In accordance with applicable specifications, gate valves should be installed on the main line below the dam and on any branch line to facilitate control of the rate of discharge.

Treatment: The pond water-treatment facility consists of four general parts, (see figure 14) that is, settling basin, filtration unit, clear water storage, and disinfection area. If the turbidity does not settle out in the pond, the turbid water is mixed with suitable chemical such as alum to speed up the settling rate of suspended material. The water is passed to the filter bed where the remaining suspended material is removed. The clear water passes to a storage unit and is then disinfected.

After the treatment and disinfection equipment have been checked and are operating satisfactorily, a bacteriological examination of a water sample should be made before using for drinking or cooking.

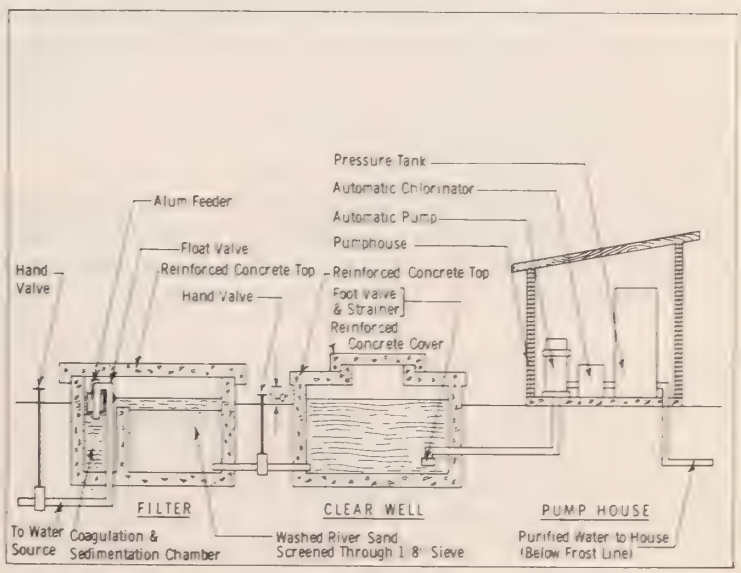


Figure 14. Pond Water-Treatment System.

The principles of treatment of individual water supplies are the same as for public water supplies. When sedimentation, coagulation, filtration, and disinfection are required for a water supply, referral is made to the chapter on Public Water Supply.

Plant Maintenance: The treatment facility should be inspected daily. The disinfection equipment should be checked to make sure it is operating satisfactorily. When chlorine disinfection

is practiced, the chlorinator and the supply of chlorine solution should be checked. The water supply should be checked daily for its chlorine residual. The water may become turbid after heavy rains and the quality may change. Increases in the amount of chlorine and coagulates used will then be required. The performance of the filter should be watched closely. When the water becomes turbid or the available quantity of water decreases, the filter should be cleaned or backwashed.

Protection from Freezing: Protection against freezing must be provided unless the plant is not operated and is drained during freezing weather. In general, the filter and pumproom should be located in a building that can be heated in winter. With suitable topography the need for heat can be eliminated by placement of the pumproom and filter underground on a hillside. Gravity drainage from the pumproom must be possible to prevent flooding. No matter what the arrangement, the filter and pumproom must be easily accessible for maintenance and operation.

Taste and Odors: (See chapters on Quality of Drinking Water and Public Water Supply.)

Weed Control: The growth of weeds around a pond should be controlled by cutting or pulling. Before weedkillers are used, the local health department should be contacted for advice since herbicides often contain compounds that are highly toxic to humans and animals. Algae in the pond should be controlled, particularly the blue-green types which produce scum and objectionable odors and which, in unusual instances, may harm livestock.

Streams

Streams receiving runoff from large uncontrolled watersheds may be the only source of water supply. The physical and bacteriological quality of surface water varies and may impose unusually or abnormally high loads on the treatment facilities. Spring runoff from thaws or a sudden downpour of rain may be contaminated as well as highly turbid.

Stream intakes should be located upstream away from sewer outlets or other sources of contamination. The water should be pumped when the silt load is low. A low water stage usually means that the temperature of the water is higher than normal, the water is of poor chemical quality, and that the water is diluted by waste. Maximum silt loads, however, occur during maximum runoff. High-water stages shortly after storms are usually the most favorable for diverting or pumping water to storage. These conditions vary and should be determined for the particular stream.

Irrigation Canals

If properly treated, irrigation water may be used as a source of domestic water supply. When return irrigation (tail water) is practiced, the water may contain large concentrations of undesirable chemicals and must be periodically analyzed for chemicals. Irrigation canal water should be treated like other surface waters.

Types of Well Pumps

Three types of pumps are commonly used in individual water distribution systems. They are the positive displacement, the centrifugal, and the jet. These pumps can be used in a water system utilizing either a ground or surface source. It is desirable in areas where electricity or other power (gasoline, diesel oil, or windmill) is available to use a power-operated pump. When a power supply is not available, a hand pump or some other manual method of supplying water must be used.

Special types of pumps with limited application for individual water supply systems include air lift pumps and hydraulic rams.

Positive Displacement Pumps. The positive displacement pump forces or displaces the water through a pumping mechanism. These pumps are of several types.

One type of positive displacement pump is the reciprocating pump. This pump consists of a mechanical device which moves a plunger back and forth in a closely fitted cylinder. The plunger is driven by the power source, and the power motion is converted from a rotating action to a reciprocating motion by the combined work of a speed reducer, crank, and a connecting rod. The cylinder, composed of a cylinder wall, plunger, and check valve, should be located near or below the static water level to eliminate the need for priming. The pumping action begins when the water enters the cylinder through a check valve. When the piston moves, the check valve closes, and in so doing forces the water through a check valve in the plunger. With each subsequent stroke, the water is forced toward the surface through the discharge pipe.

Another type of positive displacement pump is a helical or spiral rotor. The helical rotor consists of a shaft with a helical (spiral) surface which rotates in a rubber sleeve. As the shaft turns, it pockets or traps the water between the shaft and the sleeve and forces it to the upper end of the sleeve.

Other types of positive displacement pumps include the regenerative turbine type. It incorporates a rotating wheel or impeller which has a series of blades or fins (sometimes called buckets) on its outer edge and a stationary enclosure called a raceway or casting. Pressures several times that of pumps relying solely on centrifugal force can be developed.

Centrifugal Pumps. Centrifugal pumps are pumps containing a rotating impeller mounted on a shaft turned by the power source. The rotating impeller increases the velocity of the water and discharges it into a surrounding casing shaped to slow down the flow of the water and convert the velocity to pressure. This decrease of the flow further increases the pressure.

Each impeller and matching casing is called a stage. The number of stages necessary for a particular installation will be determined by the amount of water required, the pressure needed for the operation of the water system, and the height the water must be raised from the surface of the water source.

When the pressure or amount of water required is more than can be practicably or economically furnished by a single stage, additional stages are used. A pump with more than one stage is called a multistage pump. In a multistage pump water passes through each stage in succession, with an increase in pressure at each stage.

Multistage pumps commonly used in individual water systems are of the turbine and submersible types.

Turbine Pumps. The vertical drive turbine pump consists of one or more stages with the pumping unit located below the drawdown level of the water source. A vertical shaft connects the pumping assembly to a drive mechanism located above the pumping assembly. The discharge casing, pumphousing, and inlet screen are suspended from the pump base at the ground surface. The weight of the rotating portion of the pump is usually suspended by a thrust bearing located in the pump head. The intermediate pump bearings may be lubricated by either oil or water. From a sanitary point of view, lubrication of pump bearings by water is preferable, since lubricating oil may leak and contaminate the water. (Fig. 15)

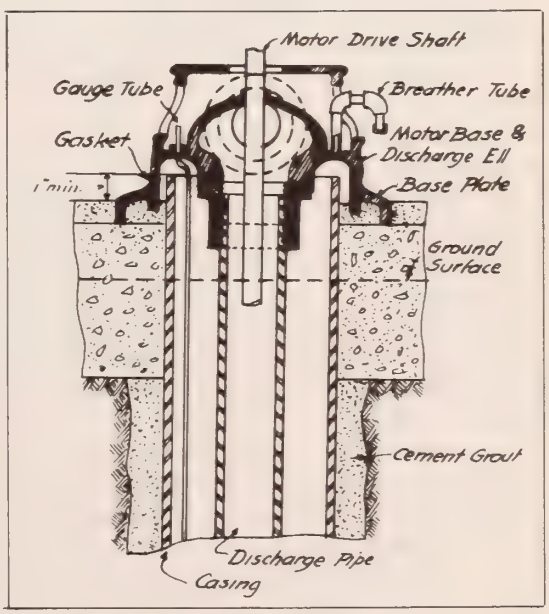


Fig. 15. Simple Arrangement for Turbine Pump

Submersible Pumps. When a centrifugal pump is driven by a closely coupled electric motor constructed for submerged operation as a single unit, it is called a submersible pump. The electrical wiring to the submersible motor must be waterproof. The electrical control should be properly grounded to

minimize the possibility of shorting and thus damaging the entire unit. The pump and motor assembly are supported by the discharge pipe; therefore, the pipe should be of such size that there is no possibility of breakage. (Fig. 21)

The turbine or submersible pump forces water directly into the distribution system; therefore, the pump assembly must be located below the maximum drawdown level. This type of pump can deliver water across a wide range of pressures with the only limiting factor being the size of the unit and the horsepower applied. When sand is present or anticipated in the water source, special precautions should be taken before this type of pump is used since the abrasion action of the sand during pumping will shorten the life of the pump.

Jet (Ejector Pumps). (Fig. 16.) Jet pumps are actually combined centrifugal and ejector pumps. A portion of the discharged water from the centrifugal pump is diverted through a nozzle and venturi tube. A pressure zone lower than that of the surrounding area exists in the venturi tube; therefore, water from the source (well) flows into this area of reduced pressure. The velocity of the water from the nozzle pushes it through the pipe toward the surface where the centrifugal pump can lift it by suction. The centrifugal pump then forces it into the distribution system.

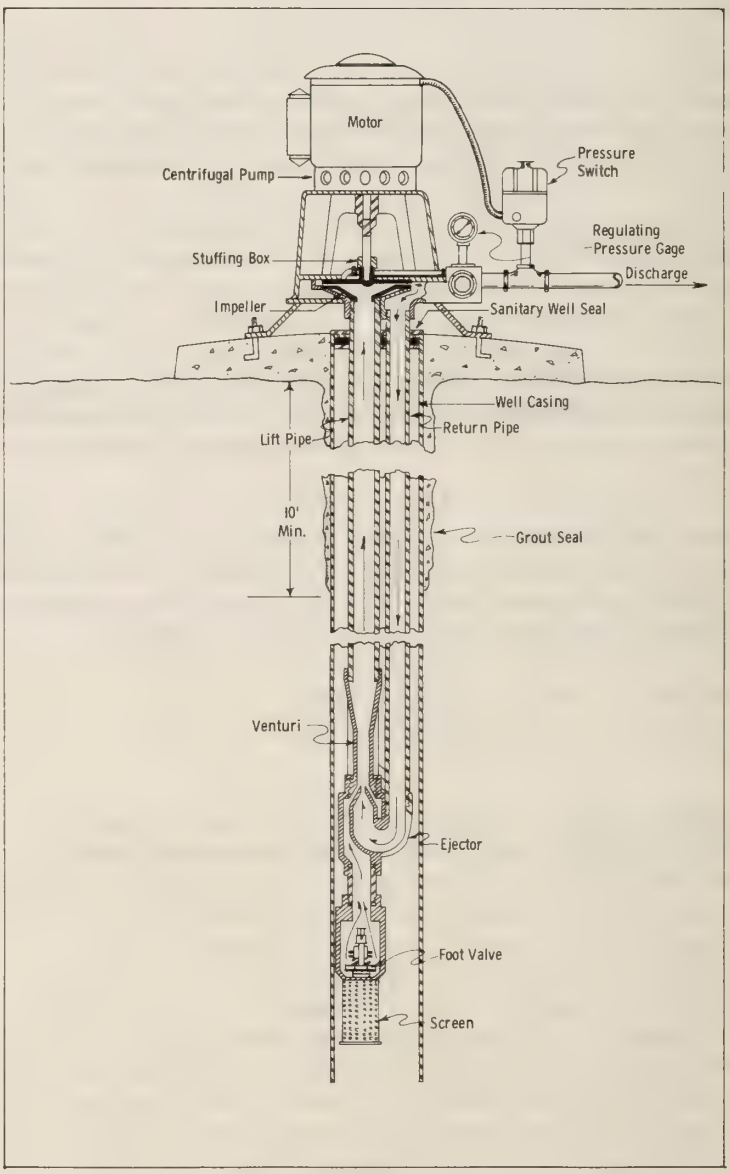


Figure 16. Jet Pump.

Selection of Pumping Equipment. The type of pump selected for a particular installation should be determined on the basis of the following fundamental considerations.

1. Yield of the well or water source
2. Daily needs and instantaneous demand of the users
3. Size of pressure or storage tank
4. Size and alignment of the well casing
5. Total operating head pressure of the pump at normal delivery rates, including lift and all friction losses
6. Difference in elevation between ground level and water level in the well during pumping
7. Availability of power
8. Ease of maintenance and availability of replacement parts
9. First cost and economy of operation
10. Reliability of pumping equipment

The rate of water delivery required depends on the time of effective pump operation as related to the total water consumption between periods of pumping. Total water use can be deter-

mined from Table 1. The period of pump operation depends upon the quantity of water on hand to meet peak demands and the storage available. If the well yield will permit, a pump with a minimum capacity of 600 gph should be used for the average home water system.

When the well yield is low in comparison to peak demand requirements, an appropriate increase in the storage capacity is required. The life of an electric drive motor will be reduced when there is excessive starting and stopping. The water system, therefore, should be designed so that the interval between starting and stopping is as long as is practicable but not less than 1 minute.

Pumps that deliver water to pressure tanks with limited capacity should be capable of delivering at least 120 percent of the peak demand. When storage for more than one day is provided, the pump should be capable of delivering three times the maximum daily rate of water consumption. Pumps delivering water to storage reservoirs with a capacity of more than one week's demand should have a capacity of 150 percent of the maximum average daily rate of water consumption.

The total operating head of a pump consists of the lift (vertical distance from pumping level of the water source to the pump), and the friction losses in the pipe and fittings from water source to pump, and the discharge pressure. (Fig. 20)

Pumps that cannot be wholly submerged during pumping are dependent on suction to raise the water from the source by reducing the pressure in the pump column, or creating a suction. The vertical distance from the source (pumping level) to the axis of the pump is called the suction lift, and for practical purposes cannot exceed between 15-25 feet, depending on the design of the pump and the altitude above sea level where it is used.

Shallow well pumps should be installed with a foot valve at the bottom of the suction line or with a check valve in the suction line in order to maintain pump prime.

The selection of a pump for any specific installation should be based on competent advice (health, agriculture, geological survey departments, well-drillers, consulting engineering firms, pump manufacturers or representatives).

A selected pump should always carry a written warranty covering materials and mechanical performance over a specified period of time after being placed in operation.

Sanitary Protection of Pumping Facilities

The pump equipment for either power-driven or manual systems should be so constructed and installed as to prevent the entrance of contamination or objectionable material either into the well or into the water that is being pumped. The following factors which should be considered.

1. Designing the pump head or enclosure so as to prevent pollution of the water by lubricants or other maintenance materials used during operation of the equipment. Pollution from hand contact, dust, rain, birds, flies, rodents or animals, and similar sources should be prevented from reaching the water chamber of the pump or the source of supply.
2. Designing the pump base or enclosure so as to facilitate the installation of a sanitary well seal within the well cover or casing.
3. Installation of the pumping portion of the assembly near or below the static water level in the well so that priming will not be necessary.
4. Designing for frost protection, including pump drainage within the well when necessary.
5. Overall design consideration so as to best facilitate necessary maintenance and repair, including overhead clearance for removing the drop pipe and other accessories.

When planning for sanitary protection of a pump, specific types of installations must be considered. The following points should be considered for the different types of installations.

Table 7. --Information on pumps

Type of pump	Practical suction lift[1]	Usual well-pumping depth	Usual pressure heads	Advantages	Disadvantages	Remarks
Reciprocating:						
1. Shallow well	22–25 ft.	22–25 ft.	100–200 ft.	1. Positive action. 2. Discharge against variable heads. 3. Pumps water containing sand and silt. 4. Especially adapted to low capacity and high lifts.	1. Pulsating discharge. 2. Subject to vibration and noise. 3. Maintenance cost may be high. 4. May cause destructive pressure if operated against closed valve.	1. Best suited for capacities of 5–25 gpm against moderate to high heads. 2. Adaptable to hand operation. 3. Can be installed in very small diameter wells (2" casing). 4. Pump must be set directly over well (deep well only).
2. Deep well	22–25 ft.	Up to 600 ft.	Up to 600 ft. above cylinder.			
Centrifugal:						
1. Shallow well						
a. straight centrifugal (single stage)	20 ft. max.	10–20 ft.	100–150 ft.	1. Smooth, even flow. 2. Pumps water containing sand and silt. 3. Pressure on system is even and free from shock. 4. Low-starting torque. 5. Usually reliable and good service life.	1. Loses prime easily. 2. Efficiency depends on operating under design heads and speed.	1. Very efficient pump for capacities above 50 gpm and heads up to about 150 ft.
b. Regenerative vane turbine type (single impeller)	28 ft. max.	28 ft.	100–200 ft.	1. Same as straight centrifugal except not suitable for pumping water containing sand or silt. 2. They are self-priming.	1. Same as straight centrifugal except maintains priming easily.	1. Reduction in pressure with increased capacity not as severe as straight centrifugal.
2. Deep well						
a. Vertical line shaft turbine (multistage)	Impellers submerged.	50–300 ft.	100–900 ft.	1. Same as shallow well turbine.	1. Efficiency depends on operating under design head and speed. 2. Requires straight well large enough for turbine bowls and housing. 3. Lubrication and alignment of shaft critical. 4. Abrasion from sand.	
b. Submersible turbine (multistage)	Pump and motor submerged.	50–400 ft.	50–400 ft.	1. Same as shallow well turbine. 2. Easy to frost-proof installation. 3. Short pump shaft to motor.	1. Repair to motor or pump requires pulling from well. 2. Sealing of electrical equipment from water vapor critical. 3. Abrasion from sand.	1. Difficulty with sealing has caused uncertainty as to service life to date.
Jet:						
1. Shallow well	15–20 ft. below ejector.	Up to 15–20 ft. below ejector.	80–150 ft.	1. High capacity at low heads. 2. Simple in operation. 3. Does not have to be installed over the well. 4. No moving parts in the well.	1. Capacity reduces as lift increases. 2. Air in suction or return line will stop pumping.	
2. Deep well	15–20 ft. below ejector.	25–120 ft. 200 ft. max.	80–150 ft.	1. Same as shallow well jet.	1. Same as shallow well jet.	1. The amount of water returned to ejector increases with increased lift—50% of total water pumped at 50 ft. lift and 75% at 100 ft. lift.
Rotary:						
1. Shallow well (gear type)	22 ft.	22 ft.	50–250 ft.	1. Positive action. 2. Discharge constant under varible heads. 3. Efficient operation.	1. Subject to rapid wear if water contains sand or silt. 2. Wear of gears reduces efficiency.	
2. Deep well (helical rotary type).	Usually submerged.	50–500 ft.	100–500 ft.	1. Same as shallow well rotary. 2. Only one moving pump device in well.	1. Same as shallow well rotary except no gear wear.	1. A cutless rubber stator increases life of pump. Flexible drive coupling has been weak point in pump. Best adapted for low capacity and high heads.

[1] Practical suction lift at sea level. Reduce lift 1 foot for each 1,000 ft. above sea level.

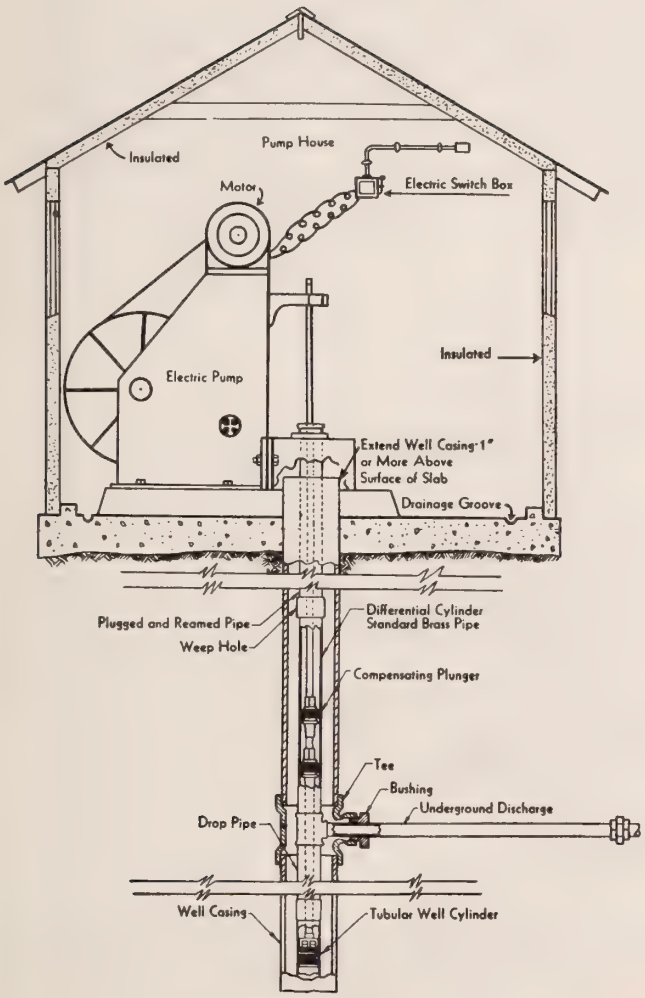


Fig. 17 Typical Power Pump Installation Tee and Underground Arrangement to Discharge Water Below Frost Line

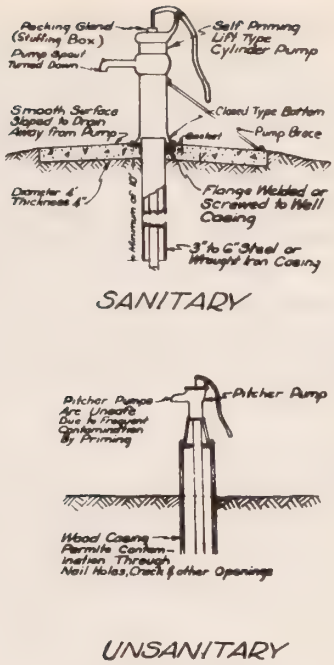

Packing Gland (Stuffing Box)
Pump Spout Turned Down
Self Priming Lift Type Cylinder Pump
Smooth Surface Sloped to Drain Away from Pump
Cleanout
Closed Type Bottom
Pump Brace
Diameter 4' Thickness 4"
Minimum of 8'
Flange Welded or Screwed to Well Casing
3" to 6" Steel or Wrought Iron Casing
SANITARY
Pitcher Pumps Are Unsafe Due to Frequent Contamination By Priming
Pitcher Pump
Wood Casing Permits Contamination Through Nail Holes, Crack & other Openings
UNSANITARY

Fig. 18 Sanitary and Unsanitary Installation for Hand Pump

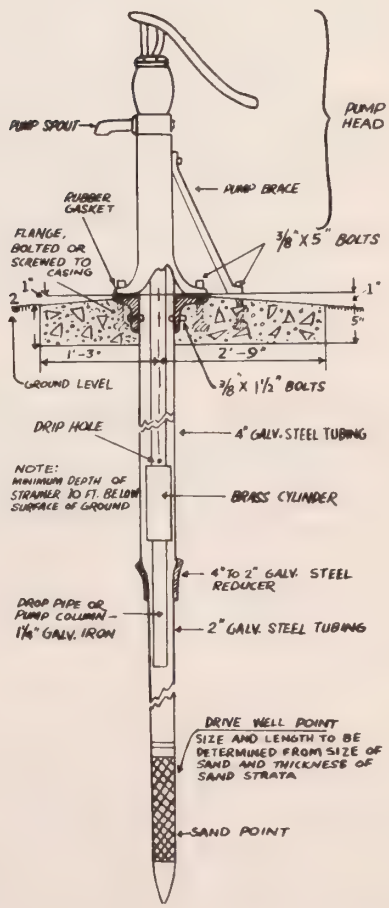


Fig. 19. Driven Well Pump Details

Over-the-Well Installation

General. The most common type of pump installation is the over-the-well type. The pump should be placed on a raised, concrete base rising at least 4 inches above the pumphouse floor or on an approved metal base or pumpstand furnished with the particular pump. The top of the base should slope to allow for the drainage of any water that may collect on it.

Power Pumps. All well casings for power-pump installations should extend at least 6 inches above the pumproom floor or platform slab. The base plate of a power-operated pump placed over the well should be designed to form a watertight seal with the well cover or casing. The base should be recessed to permit the casing or pipesleeve to extend into it at least 1 inch above the foundation upon which the pump base rests. The annular space between the casing and suction and/or discharge pipe should be closed tightly with an acceptable sanitary well seal. In installations where an open-type pump is used, the well casing or pipesleeve should extend at least 6 inches above the floor of the pumphouse. Powered pump equipment is the most commonly used type for well installations; but, of course, when power is not available, hand-operated pumps are used.

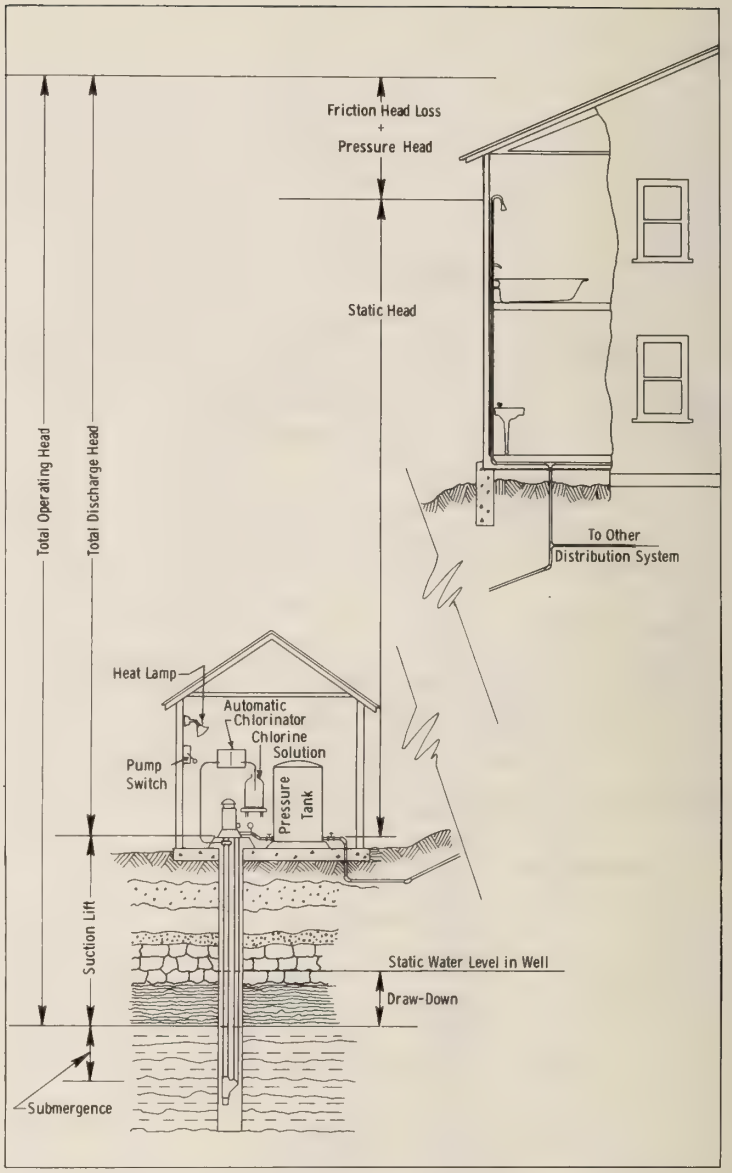


Figure 20. Components of Total Operating Head in Well Pump Installations

Hand Pumps. A trough should carry all waste water to a point at least 15 feet from the well. From that point a small ditch should carry the water away. The pump should be a force pump with a solid seamless base and should have a packing gland at the top around the rod. Pitcher pumps and split base pumps or any pumps with openings through the base are not approved due to the possibility of contamination.

a. Hand pumps should be of the force type with cylinders placed below or near the water level so that priming will not be necessary. Direct-lift, chain-lift, and bucket pumps are not satisfactory.

b. The pump base should be of the solid one-piece recessed type, cast integrally with or threaded to the pump column or stand. Two-piece (split) open-work and adjustable bases are not satisfactory.

c. The pump base should be of sufficient diameter and depth to permit at least a 6 inch well casing or 6 inch pipe sleeve used in the top of a dug well to extend at least 1 inch above the pedestal on which the pump base will rest.

d. Provisions should be made for fastening the pump base rigidly to the pedestal and well top to prevent movement of the pump. This may be accomplished by securing the pump by means of bolts imbedded in the concrete, or by the use of a flange or pump stand secured to the casing top. A pump base should be used to provide stability to the pump setting. Suitable gask-

ets should be used between the pump base and the pedestal or the flange, as the case may be.

e. The pump head should be designed to exclude contamination by hands, dust, rain, birds, flies, and similar sources from the water chamber of the pump head. Force pumps are reasonably protected against such contamination by the stuffing box which surrounds the pump rod. Ordinary lift pumps with a slotted pump-head top are open to contamination and should not be used.

f. The pump spout should be of the closed, downward-directed type. The open type commonly used on "pitcher pumps" should not be used. Suitable types of hand pumps and pump settings as described in this section are shown in Figs. 18 and 19.

g. Pumping equipment can be obtained which makes the use of pits or sub-ground-level pump rooms unnecessary. Standard parts can be purchased and assembled in such a way as to accomplish the same results. With double tubular wells, i.e., wells which have a casing and a drop pipe, pump cylinders and "weep holes" in the drop pipe, or bleeders, are located inside the well casing so that pump drainage can run back into the well. A method of providing an underground discharge with the use of a pit below ground surface is shown in Figs. 17 and 21. Fig. 21 is suitable where the pump cylinder diameter is larger than that of the drop line.

h. Hand-operated types of pumps which require priming should not be used.

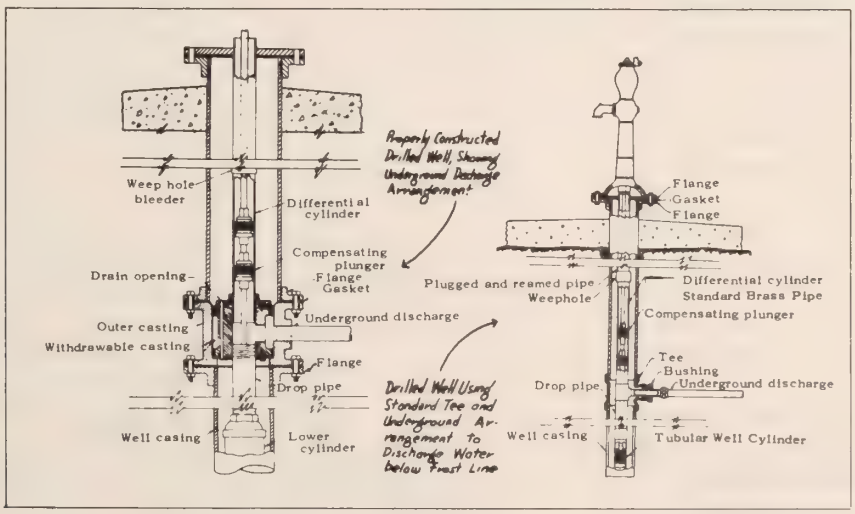
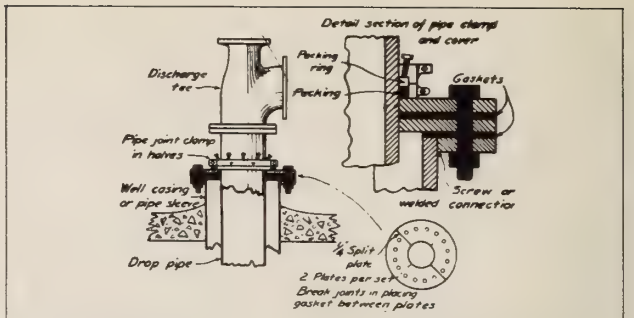


Fig. 21
Underground Discharge without Pit

Suction Pipes. All suction piping, such as that leading from detached wells or reservoirs, when laid underground should be at least 10 feet below the surface of the ground, or special protection should be provided. The surface contamination is generally retained in the upper zone of the earth, and filtration may be insufficient to prevent the contamination from reaching the suction pipe. All that part of any suction pipe within 10 feet of and below the surface of the ground should be surrounded by a watertight outer casing pipe. In the case of a suction pipe rising to a pump house, the outer casing should extend at least 13 inches above the ground and 7 inches above the platform or floor surface. The annular opening between the protective casing pipe and the suction pipe should be filled in and properly covered at the top in a manner similar to that for covering the top of a drilled well. (See Figure 22.)

The important thing to consider is the method used in sealing the annular space at the top to prevent leakage. This space is between the drop-pipe (or suction pipe) and the well casing. The space can be closed by a reducer. Bolted flanges with gaskets will work in some instances while others may have a packing gland. Oakum and lead make an easy and inexpensive seal. Sand and asphalt compounds or cement grout may be used. Whatever method is used should be approved by the health department before being installed. Asphalt has the advantage that any cracks which develop in the seal can be promptly filled with the use of a blow torch. A simple and safe method is that where the seal is provided by the pump base itself.

Horizontal suction pipes which are located underground within 10 feet of the surface may be protected by placing sufficient earth filling on the surface to provide a total of 10 feet of covering over the piping. Where this is not possible, the pipe can be encased in concrete with at least 4" covering. By placing the pumps directly over the well, sump, or reservoir, or locating the suction pipe above ground in a frost box, where necessary, the hazards of a suction pipe located less than 10 feet below ground level will be avoided.



ARRANGEMENT OF CLOSING ANNULAR SPACE BETWEEN DROP PIPE AND CASING HEAD BY SPLIT PACKING RINGS AND PLATES

Figure 22

Priming. Water for priming pumps on any water system should be taken directly from the reservoir or distribution system which is supplied with water from the original source of the water supply, or from another supply which meets the requirements of the health department. Priming devices should be so constructed that they will not expose the water to dust, drippings, or other sources of contamination.

Cooling water. Water used for cooling parts of engines, air compressors, pumps, or other equipment should not be returned to any part of the water system.

Valve boxes. Every valve box on a buried suction pipe line should project at least 6 inches above the floor if in a building or room, and at least 12 inches above the ground surface if not enclosed in a building. The top of the box should be provided with a cover of the same overlapping type as hereinbefore prescribed for manholes. Valve boxes should be of watertight construction.

Airlift systems. Where water is pumped by means of an airlife system, the air compressors should be placed in a room as free as possible from dust, and at such an elevation that flooding will be made impossible. The compressed air from the compressor should be discharged into an air storage tank so designed as to extract from the compressed air any oil or oil mist which may have entered during its passage through the compressor. In order to minimize the possibilities of oil contamination, the use of oil traps, filters, and as little

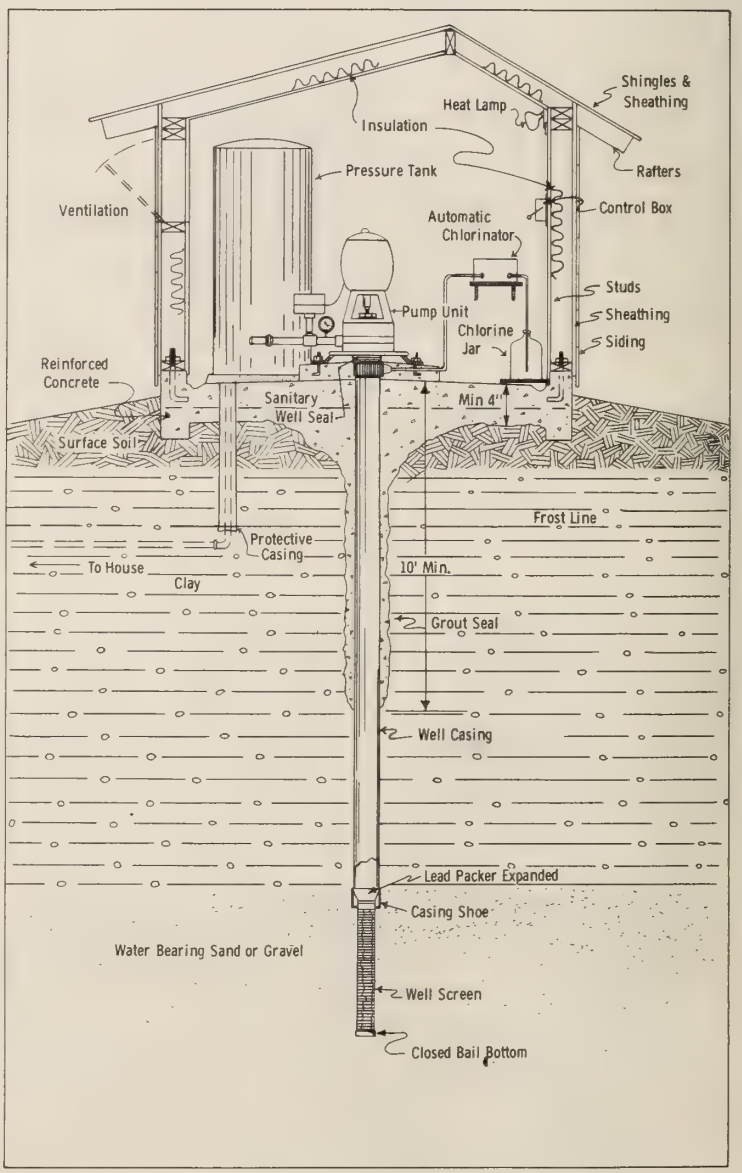


Figure 23. Pumphouse.

oil as will provide satisfactory operation of the compressor is recommended.

The air intake of any air lift system or mechanical aerating apparatus should be at least 6 feet above the floor surface if indoors and 10 feet above the ground if out of doors. The air intake should be so constructed as to prevent the entrance of birds, insects, rain, snow, or other contaminating material and to minimize the entrance of dust.

Air intakes for aerators or for pressure tanks should be located and protected as hereinbefore outlined. Locations which are dusty or poorly ventilated should be avoided. A suitable type of air inlet is shown in Fig. 28.

Hydraulic Rams. Hydraulic rams can be used to good advantage where there is a generous supply of free flowing water from a spring, an artesian well, a weir, or other source which otherwise would be wasted. They operate on the principle that a moving body of water is invested with a certain amount of energy and, being non-elastic, refuses to be stopped suddenly but will transmit this energy more gradually to another body of water by the intermediary of a space of compressed air.

The spring or overflow box is tapped by a constantly immersed, screened pipe of ample dimensions. This pipe should have a certain capacity, grade, and length for the amount of water and the elevation of delivery. (Fig. 24.)

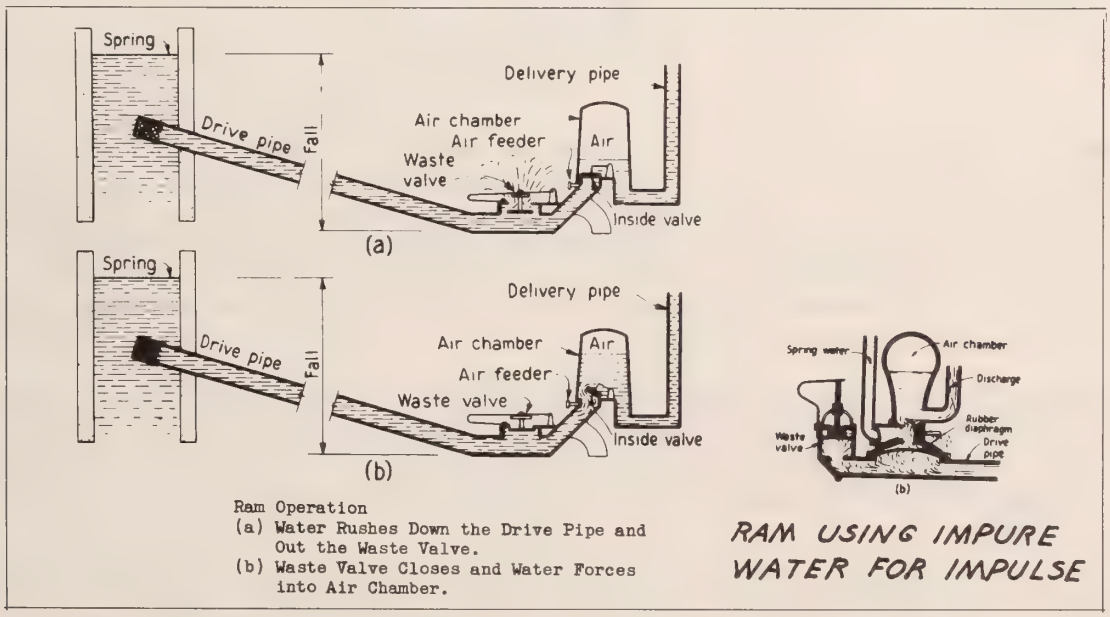


Figure 24. Operation of the Hydraulic Ram

This pipe has a short horizontal section at the lower end in which a large disk valve is placed which can be moved in a vertical way, closing or opening a hole in the top of the pipe. When the column of water is in rest, the valve is open because of the weight of the disk. Some water will flow around the disk and out of the hole. The flow will become faster and faster in little time until the pressure head between disk and the edge of the pipe becomes low enough for the water under the disk to overcome the weight of the valve, which is then closed suddenly. The momentum of the water column then forces open a check valve placed in the bottom of the air pressure chamber, which is filled with air under a pressure head equal to the delivery head of the water. Part of the water column rushes in, compresses the air until its velocity is exhausted. The check valve of the air chamber closes and the water column in the drive pipe has a reversed flow for a moment, which causes a small amount of air to be sucked in through an air feeder below the check valve and at the same time the valve in the drive pipe to be opened again, thus repeating the procedure. The air pressure in the air chamber expels the water in

that chamber until the previous delivery head is reached. Such rams therefore, if kept in clean condition, perform through the years without a stop and are, although the least effective of all water pumping equipment, by all means the cheapest.

Usually the water pumped is the same as that provided to the drive pipe and both are potable water. In cases where the drive pipe is served with water from a weir in a surface body of water, this water and the potable water pumped are kept separated in the ram. (Fig. 24) Such an installation is preferred where there is only a limited supply of potable water and an abundant supply of surface water. In some double acting rams, if acting properly, the creek water will not enter the air chamber, but in case of a defect both waters will mix. For this reason only rams in which both waters are separated with a rubber diaphragm should be allowed.

Minimum conditions are: Flow of 1 1/2 g.p.m., a fall of 24" and a drive pipe length of 25 feet. Such an installation would produce only 9 g.p.h., at 10 feet elevation. However, with a flow of 30 g.p.m., a fall of 15 feet and drive pipe length of 100 feet, 180 g.p.h. can be delivered. A slope of 2 1/2" per foot is considered most effective for the drive pipe, which should be 10 to 20% longer than the elevation of delivery.

A simple formula for determining the approximate delivery from a hydraulic ram is:

$$\text{Delivery in g.p.h.} = \frac{O \times F \times 40}{H}$$

O = g.p.m. of supply water
F = fall in feet
H = total vertical elevation from ram to discharge point

A pumphouse installed above the surface of the ground should be used. (Figure 23.) The pumproom floor should be of watertight construction, preferably concrete, and should slope uniformly away in all directions from the well casing or pipesleeve. It should be unnecessary to use an underground discharge connection if an insulated, heated pumphouse be provided. For individual installations in rural areas, two 60-watt light bulbs, a thermostatically controlled electric heater, or a heating cable will generally provide adequate protection when the pumphouse is properly insulated.

In areas where power failures may occur, an emergency, gasoline-driven power supply or pump should be considered. A natural disaster, such as a severe storm, hurricane, tornado, blizzard, or flood, may cut off power for hours or even days. A gasoline, power-driven electrical unit could supply the power requirements of the pump, basic lighting, refrigeration, and other emergency needs.

If the pumping rate lowers the water table in the well 10 feet or more, the use of well vent is recommended. The upper end of the vent pipe, protected with proper screening, should be turned downward.

Certain types of power pumps require that the pump system be filled with water for priming or water-lubrication purposes before the system is started. Water used for priming should be free of pollution.

It is desirable to provide a water-sampling tap on the discharge line from power pumps.

Because of the pollution hazards involved, a well pit to house the pumping equipment or to permit accessibility to the top of the well is not recommended.

Pitless Units. A commercial unit known as the "pitless adapter" is available to eliminate well pit construction. A specially designed connection between the underground horizontal discharge pipe and the vertical casing pipe makes it possible to terminate the permanent, watertight casing of the well at a safe height (12 inches) above the established grade level. The underground section of the discharge pipe is permanently installed and it is not necessary to disturb it when repairing the pump or cleaning the well. (Figure 25.)

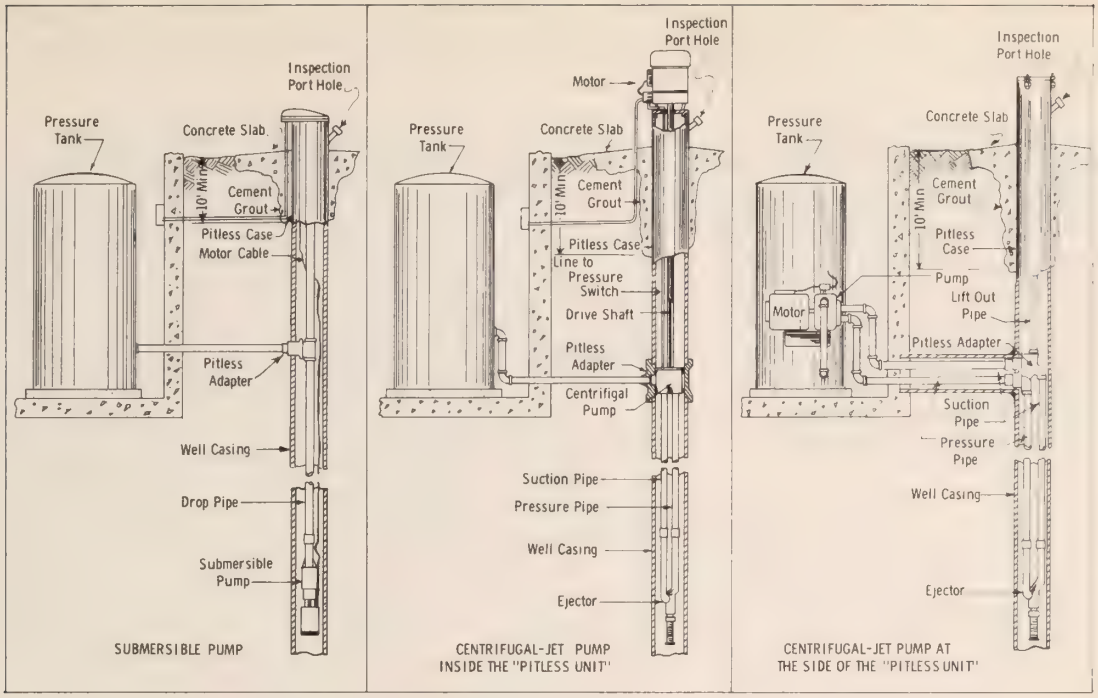


Figure 25. Pitless Units.

Before considering the installation of the pitless unit, State or local health authorities should be contacted for advice or applicable regulations concerning the use of such a device.

Distribution

Pipe and Fittings. For reasons of economy and ease of construction, distribution lines for small water systems are ordinarily made up with standard threaded, galvanized iron or steel pipe and fittings. Other types of pipes used are cast iron, asbestos-cement, concrete, plastic, and copper. Under certain conditions and in certain areas, it may be necessary to use protective coatings, galvanizing, or have the pipes dipped or wrapped. When corrosive water or soil is encountered, copper, brass, wrought iron, plastic or cast iron pipe, although usually more expensive initially, will have a longer, more useful life. Cast iron is not usually available in sizes below two inches in diameter; hence, its use is restricted to the larger transmission lines.

Plastic pipe for cold water piping is usually simple to install, has a low initial cost, and has good hydraulic properties. When used in a domestic water system, plastic pipe should be certified by an acceptable testing laboratory (such as the National Sanitation Foundation) as being nontoxic and nontaste-producing. It should be protected against crushing and from attack by rodents. Asbestos-cement pipe for water systems, available in the sizes required, has the advantages of ease of installation and moderate resistance to corrosion.

Fittings are usually available in the same sizes and materials as piping, but valves are generally cast in bronze or other alloys. In certain soils the use of dissimilar metals in fittings and pipe may create electrolytic corrosion problems. The use of nonconductive plastic inserts between pipe and fittings or the installation of sacrificial anodes is helpful in minimizing such corrosion.

Pipes should be laid as straight as possible in trenches, with air-relief valves or hydrants located at the high points on the line. Failure to provide for the release of accumulated air in a pipeline on hilly ground may greatly reduce the capacity of the line. It is necessary that

pipeline trenches be excavated deep enough to prevent freezing in the winter. Pipes placed in trenches at a depth of more than three feet will help to keep the water in the pipeline cool during the summer months.

Pipe Capacity and Head Loss. The pipeline selected should be adequate to deliver the required peak flow of water without excessive loss of head, i.e, without decreasing the discharge pressure below a desirable minimum. The normal operating water pressure for household or domestic use ranges from 15 to 60 pounds per square inch,[1] or about 35 to 140 feet of head at the fixture.

The capacity of a pipeline is determined by its size, length, and interior surface condition. Assuming that the length of the pipe is fixed and its interior condition established by the type of material, the usual problem in design of a pipeline is that of determining the required diameter.

The correct pipe size can be selected with the aid of figure 26 which gives size as a function of head loss, H, length of pipeline, L, and peak discharge, Q. As an example of the use of figure 26, suppose that a home and farm installation be served by a reservoir a minimum distance of 500 feet from the point of use, one whose surface elevation is at least 150 feet above the level of domestic service, and in which a minimum service pressure of 30 pounds per square inch is required. It will be necessary first to determine the maximum operating head loss, i.e., the difference in total head and the required pressure head at the service.

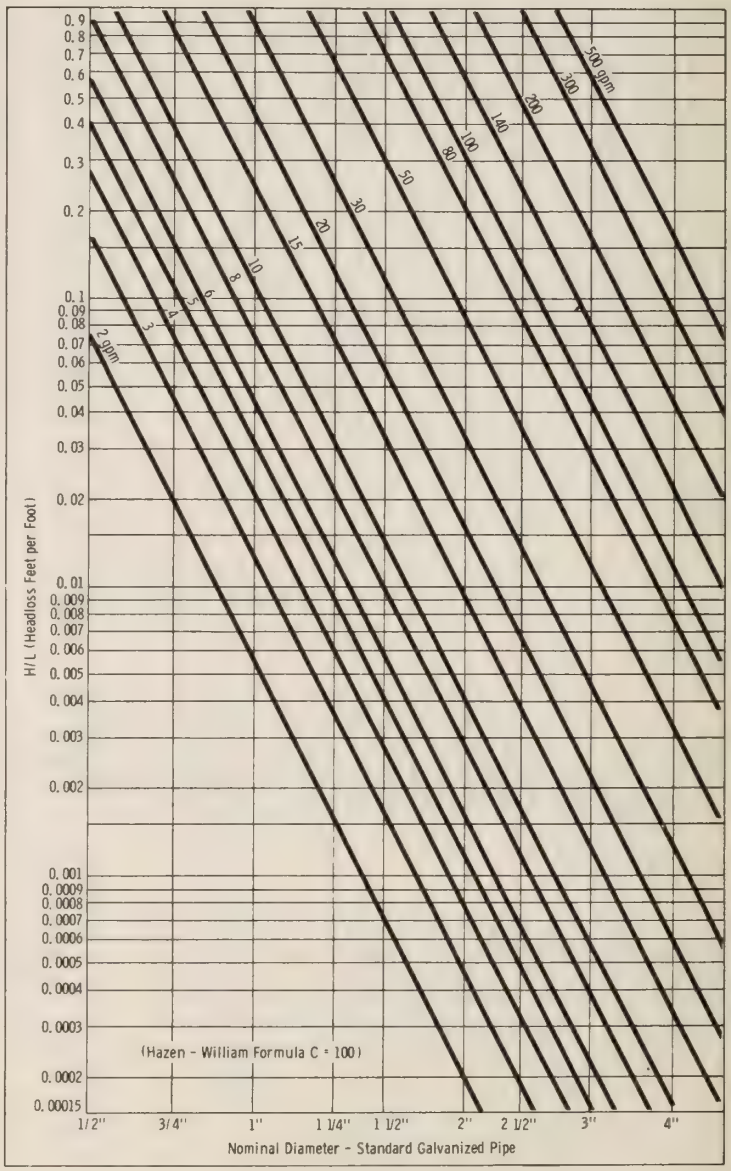


Figure 26

$$H = 150 - 2.3 \times 30 = 150 - 69 = 81 \text{ feet}$$

The maximum peak demand which must be delivered by the pipeline is determined to be 30 gallons per minute.

$$Q = 30 \text{ gallons per minute}$$

[1] One pound per square inch is the pressure produced by a column of water 2.31 feet high.

The hydraulic gradient is 0.162 feet per foot.

$$\frac{H}{L} = \frac{81}{500} = 0.162 \text{ feet per foot}$$

Entering Figure 26 with the computed values of H/L and Q, one finds that the required standard galvanized pipe size is approximately 1-3/8 inches. Since pipes are available only in standard dimensions, standard pipe of 1-1/2 inches in diameter, (the next size) should be used.

Additional head losses may be expected from the inclusion of fittings in the pipeline. These losses may be expressed in terms of the equivalent to the length and size of pipe which would produce an equivalent loss if, instead of adding fittings, we added additional pipe. Table 8 lists some common fitting losses in terms of an equivalent pipe length.

Table 8.--Allowance in equivalent length of pipe for friction loss in valves and threaded fittings

Diameter of fitting	90° std. ell	45° std. ell	90° side tee	Coupling or straight run	Gate valve	Globe valve	Angle valve
Inches	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
⅜	1	0.6	1.5	0.3	0.2	8	4
½	2	1.2	3	0.6	0.4	15	8
¾	2.5	1.5	4	0.8	0.5	20	12
1	3	1.8	5	0.9	0.6	25	15
1¼	4	2.4	6	1.2	0.8	35	18
1½	5	3	7	1.5	1.0	45	22
2	7	4	10	2	1.3	55	28
2½	8	5	12	2.5	1.6	65	34
3	10	6	15	3	2	80	40
3½	12	7	18	3.6	2.4	100	50
4	14	8	21	4	2.7	125	55
5	17	10	25	5	3.3	140	70
6	20	12	30	6	4	165	80

In the example given above the inclusion of two gate valves (open), two standard elbows, and two standard tees (through) would produce a head loss equivalent to 15 feet of 1-1/2 inch pipe. From figure 26, one finds that by using 515 feet of 1-1/2 inch pipe instead of the actual length of 500 feet (H/L=0.157), the capacity of the system for the same total head loss is about 38 gallons per minute, a satisfactory discharge.

It can be seen from this example that fitting losses are not particularly important for fairly long pipelines, say greater than about 300 feet. For pipelines less than 300 feet, fitting losses are very important and have a direct bearing on pipe selected; therefore, they should be calculated carefully.

Globe valves which do produce large head losses should be avoided in main transmission lines for small water systems.

Interior piping, fittings, and accessories should conform to the minimum requirements for plumbing of the National Plumbing Code[2] or equivalent applicable plumbing code of the locality.

Protection of Distribution Systems. The sanitary protection of new or repaired pipelines can be facilitated by proper attention to certain details of construction. All connections should be

[2]Obtainable at the American Society of Mechanical Engineers, 29 West 39th Street, New York 18, New York.

made under dry conditions, either in a dry trench or, if it be not possible to completely dewater the trench, above the ground surface. Soiled piping should be thoroughly cleaned and disinfected before connections are made. Flush valves or clean-outs should be provided at low points where there is no possibility of flooding.

When not properly designed or installed, frostproof hydrants may permit contamination to enter the water system. Such hydrants should be provided with suitable drainage to a free atmosphere outlet where possible. The drainage from the base of the hydrant should not be connected to a seepage pit which is subject to pollution or to a sewer. The water supply inlet to water tanks used for stock, laundry tubs, and other similar installations should be placed with an air gap (twice pipe diameter) above the flooding level of the fixtures to prevent danger of back siphonage. There should be no cross-connection, auxiliary intake, bypass, or other piping arrangement whereby polluted water or water of questionable quality can be discharged or drawn into the domestic water supply system.

Before a distribution system is placed in service it should be completely flushed and disinfected.

Disinfection of Water-Distribution System. These instructions cover the disinfection of water distribution systems and attendant standpipes or tanks. It is always necessary to disinfect a water system before placing it in use under the following conditions:

1. Disinfection of a system which has been in service with raw or polluted water, preparatory to transferring the service to treated water.
2. Disinfection of a new system upon completion and preparatory to placing in operation with treated water or water of satisfactory quality.
3. Disinfection of a system after completion of maintenance and repair operations.

Procedure: The entire system, including tank or standpipe, should be thoroughly flushed with water to remove any sediment which may have collected during operation with raw water. Following flushing, the system should be filled with a disinfecting solution of calcium hypochlorite and treated water. This solution is prepared by adding 1.2 pounds of high-test 70% calcium hypochlorite to each 1,000 gallons of water. A mixture of this kind provides a solution having not less than 100 mg/l of available chlorine.

The disinfectant should be retained in the system, tank, or standpipe, if included, for not less than 24 hours, then examined for residual chlorine and drained out. If no residual chlorine is found present, the process should be repeated. The system is next flushed with treated water and put into operation.

Storage

Determination of Storage Volume. Three types of storage facilities are commonly employed for individual water supply systems. They are pressure tanks, elevated storage tanks, and ground-level reservoirs and cisterns.

When ground-water sources are used for a water supply, the water-bearing formation tapped by one or more wells constitutes a natural storage area. The result is that only small artificial storage facilities may be needed.

Pressure Tanks. Pressure in a distribution system served by a pneumatic tank is maintained by pumping water directly to the tank from the source. This pumping action compresses a volume of entrapped air. The air pressure equal to the water pressure in the tank can be controlled between desired limits by means of pressure switches which stop the pump at the maximum setting and start it at the minimum setting. The capacity of pressure tanks is usually small when compared to the total daily water consumption. Tanks are customarily designed to accommodate only momentary peak demands because only 10 to 20 percent to tank capacity is available. The maximum steady demand which can be delivered by a pneumatic system is equal to the pump capacity.

Generally, the pressure tank should be approximately 10 times the pump capacity in gallons per minute. When the well yield permits, it is advisable to select a pump large enough to satisfy the peak demand periods.

Pressure tanks for individual home installations should have a capacity of at least 42 gallons or about 10 or 15 gallons per person served.

The following equation is suggested for use in estimating the size of a pressure storage tank needed in larger water supply systems. The volume can be computed with the aid of the formula below.[3]

$$Q = \frac{Qm}{1 - \frac{P_1}{P_2}}$$

Where Q is the tank volume in gallons, Qm is equal to 15 minutes of storage at peak rate, P_1 is the minimum absolute operating pressure (gauge pressure plus atmospheric pressure or 14.7 pounds per square inch), and P_2 is the maximum absolute pressure. As an example of the use of the equation, suppose that a pressure tank were to be used for a larger water system which has a peak demand of 30 gallons per minute and that the gauge pressure on the tank could be allowed to vary from 40 to 60 pounds per square inch. Then

$$\frac{P_1}{P_2} = \frac{40 + 14.7}{60 + 14.7} = 0.73, \text{ and } Qm = 15 \times 30 = 450^3$$

A tank which holds 1667 gallons is required.

$$Q = \frac{450}{1\text{-}0.73} = 1667 \text{ gallons}$$

When a pressure tank is provided in the distribution system there is no difficulty with water hammer. Sometimes it may be necessary to provide an air chamber on the discharge line from the well located near the pump to minimize the effects caused by water hammer.

Elevated Storage. Elevated tanks should have a capacity which is at least equal to two days' average consumption requirement. Larger storage volume may be necessary to meet special demands such as firefighting or equipment cleanup operations.

Ground-Level Reservoirs and Cisterns. Reservoirs which receive surface runoff should generally be large enough to supply the average daily demand over a drought period of maximum length. Cisterns are customarily designed with sufficient capacity to provide water during periods less than one year in duration.

Protection of Storage Facilities. Suitable storage facilities for relatively small systems may be constructed of concrete, steel, brick, and sometimes of wood above the land surface, or of concrete or brick if partially or wholly below the ground surface. Such storage installations should receive the same care as cistern installations in the selection of a suitable location and provision against contamination. Asphalt or tar for waterproofing the interior of storage units is not recommended because of the objectionable taste imparted to the water and the possibility of undesirable chemical reaction with the materials used for treatment. Specifications covering the painting of water tanks are available from the American Water Works Association. Appropriate Federal, State, or local health agencies should be consulted relative to approved paint coatings for interior tank use.

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[3] J. A. Salvator, Jr., Environmental Sanitation (New York, John Wiley and Sons, 1958).

All storage tanks for domestic water supply should be completely covered and so constructed as to prevent the possibility of pollution of the tank contents by outside water or other foreign matter.

Figs. 27 and 28 show some details for manhole covers and piping connections to prevent the entrance of pollution from surface drainage. Concrete and brick tanks should be made watertight by a lining of rich cement mortar. Wood tanks are generally constructed of redwood or cypress and while filled they will remain watertight. All tanks require adequate screening of any openings to protect against the entrance of small animals, mosquitoes, flies, and other small insects.

Tanks containing water to be used for livestock should be partially covered and so constructed that cattle will not enter the tank. The area around the tank should be sloped to drain away from the tank.

Figure 27 shows a typical concrete reservoir with screened inlet and outlet pipes. This figure also illustrates the sanitary manhole cover. The cover should overlap by at least 2 inches a rim elevated at least 4 inches to prevent drainage from entering the reservoir. This type of manhole frame and cover should be designed so that it may be locked to prevent access by unauthorized persons.

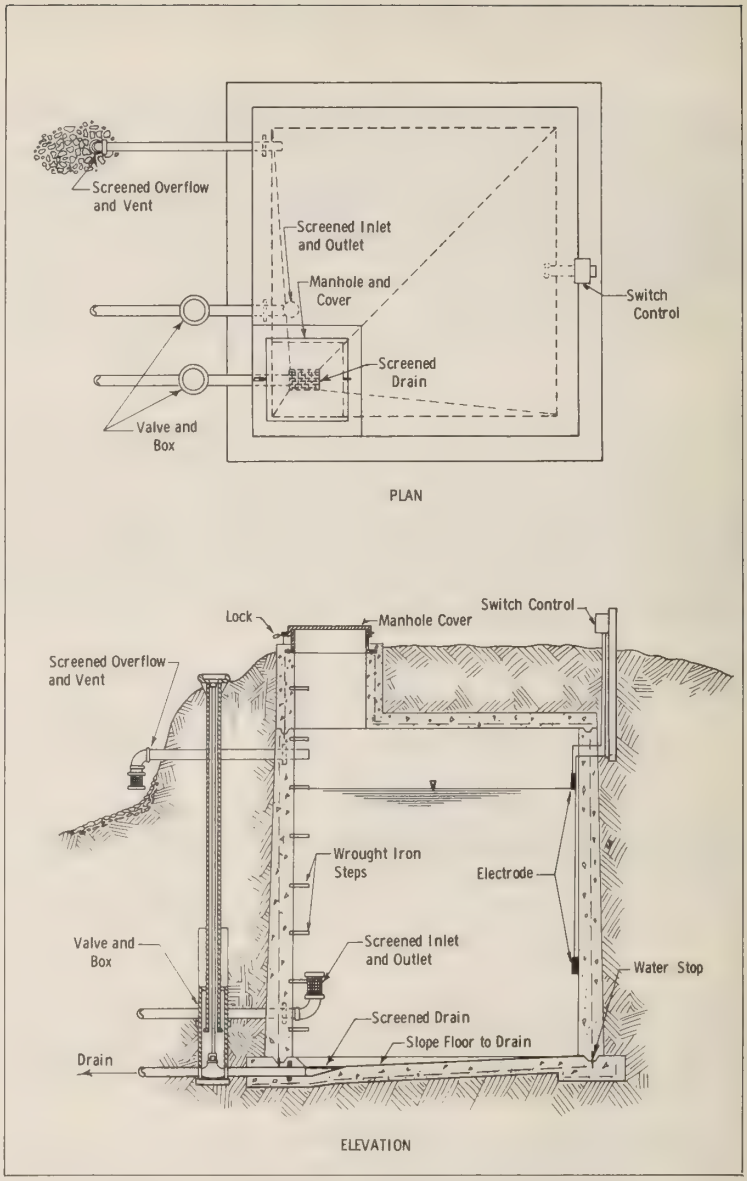

Figure 27. Typical Concrete Reservoir.

The water in storage tanks, cisterns, or pipelines should not be polluted with an emergency water supply that has been polluted at its source or in transit.

Disinfection of storage facilities subsequent to construction or repair should be carried out in accordance with the recommendations stated under "Disinfection of Water Distribution System" in this chapter.

Treatment of Ground-water Supplies. Ground water is not only used for rural private wells, but in many instances it is also used for rural and urban public water supplies. In many areas where a sufficient quantity of surface water is not available of such a quality that no treatment other than chlorination be needed, ground water supplies are used very effectively. A ground water supply is preferable in many instances to a surface water supply for which treatment would be needed, especially for public supplies of small communities which could not afford to employ a competent operator.

However, treatment of underground waters may become necessary where safe sources are not available, where changes in sanitary conditions occur in existing supplies, or where the water is too hard or contains too much iron and manganese for convenient household use.

It is recommended, however, that in order to minimize the hazards resulting from an overloading of the treatment plant or from a failure of the chlorinating equipment, and in order that the treatment be reserved as a factor of safety as far as possible, the principles and requirements for untreated underground waters be complied with as regards location, construction, and operation.

As stated, it is necessary to use treatment where the water contains harmful minerals and when there is a possibility of contamination reaching the water underground and rendering it unsafe for domestic use. Treatment is also recommended where the water is too hard, is corrosive, or contains too much iron or manganese. Treatment, however, should not be used permanently to overcome a defect of construction which can and should be corrected.

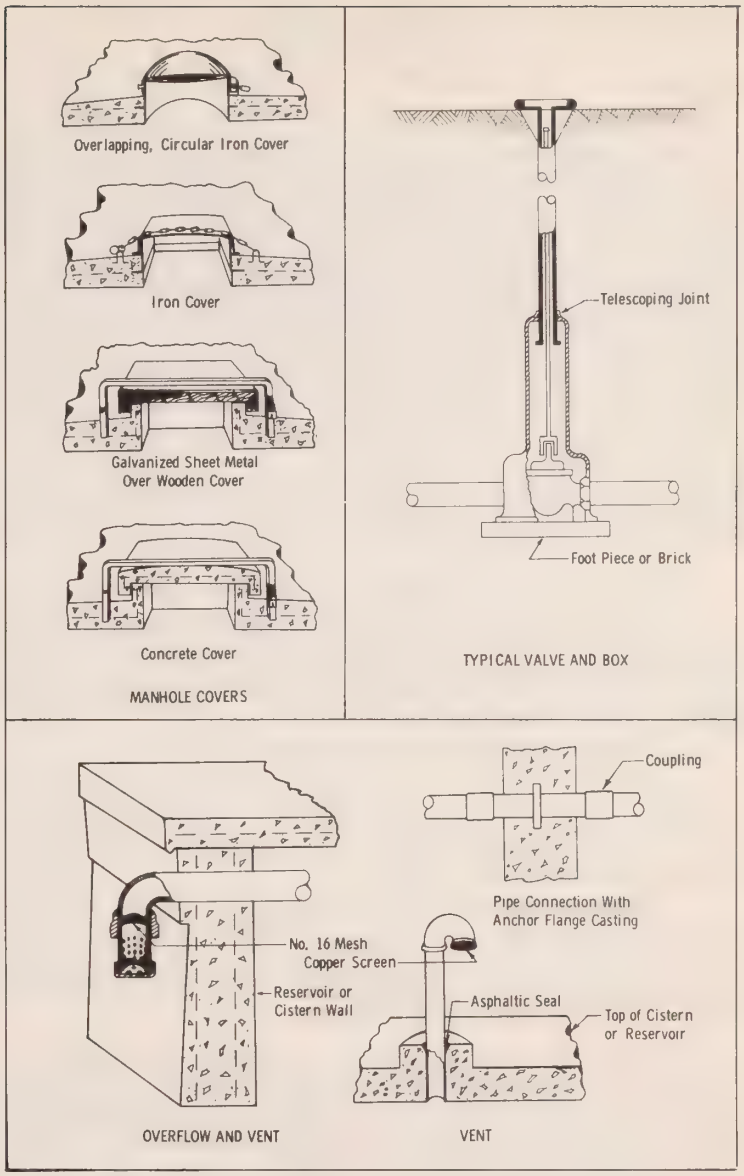

Figure 28. Typical Valve and Box, Manhole Covers, and Piping Installations.

Where a treated underground supply is in use and an equally good untreated supply can be obtained, the treated supply should be considered as temporary, to be used only until the untreated supply can be made available. Treatment may then be used as an additional safeguard.

On a site where the earth formations permit the rapid movement of ground-water such as coarse gravel, fissured rock, solution channels, and similar formations, the ground-water cannot be considered safe, and adequate treatment should be provided.

As far as possible, systems of treated underground water supplies should be constructed in accordance with the requirements governing untreated underground water supplies.

The degree of contamination of underground waters divides the required treatment into two general groups: (1) Chlorination and storage only, and (2) sedimentation, filtration, and chlorination.

Where the underground water is of good physical quality and only a possible or intermittent low degree of contamination is found, simple chlorination and storage before consumption should

be provided. See Chart 1. The water must meet the requirements of the U. S. Public Health Service Standards for Drinking Water.

Sampling

It should be borne in mind that if wells be not properly constructed and be subject to contamination, the sterilization has only a temporary effect. Sterilization affects only the water in the well at the time of treatment, and improperly constructed wells may be contaminated a few minutes after treatment. For this reason, no samples should be taken of wells of which the location or physical construction cannot be approved as sanitary. In deep wells of sanitary construction the chlorine may not penetrate to the bottom of the well to effect complete sterilization. In order to insure a safe water supply, a sample should be collected for bacteriological examination from such wells after chlorination and after the well has been pumped clear of any chlorine residual. These examinations are made in the state bacteriological laboratories. The sampling of water from private individual wells is not a routine procedure.

In the event that bacteriological samples must be obtained without technical assistance, it is possible to insure satisfactory results by carefully following these steps:

1. Use a sterile sample bottle provided by the laboratory that will examine the sample.
2. Be very careful so that NOTHING except the water to be analyzed will come in contact with the inside of the bottle or the cap.
3. Inspect the outside of the faucet. If the faucet leaks around the handle, a different sampling point should be selected.
4. Clean and dry the outside of the faucet.
5. Allow the water to run for at least one-half minute before the sample of water is collected.
6. When filling the bottle, be sure that the bottle is held so that no water which contacts the hands runs into the bottle.
7. Deliver the sample immediately to the laboratory. If the delay between collection and examination exceeds 24 hours the results may not be accurate.

Methods of Emergency Disinfection (See also Inexpensive Emergency Chlorination Methods in chapter on Public Water Supply.)

1. Boiling. Vigorous boiling for ONE full minute will kill any disease-causing bacteria present in water. The flat taste of boiled water can be improved by pouring it back and forth from one container into another, by allowing it to stand for a few hours, or by adding a small pinch of salt for each quart of water boiled.

2. Chemical Treatment. When boiling is not practical, chemical disinfection should be used. The two chemicals commonly used are chlorine and iodine.

a. Chlorine (See Chart 1.)

(1) Chlorine Bleach. Common household bleach contains a chlorine compound which will disinfect water. The procedure to be followed is usually written on the label. When the necessary procedure is not given, one should find the percentage of available chlorine on the label and use the information in the following tabulation as a guide.

Available chlorine[1]	Drops per quart of clear water[2]
1%	10
4-6%	2
7-10%	1

[1]If strength is unknown add 10 drops per quart to purify.

[2]Double amount for turbid or colored water.

The treated water should be mixed thoroughly and allowed to stand for 30 minutes. The water should have a slight chlorine odor; if not, repeat the dosage and allow the water to stand for an additional 15 minutes. If the treated water has too strong a chlorine taste, it can be made more palatable by allowing the water to stand exposed to air for a few hours or by pouring it from one clean container to another several times.

(2) Granular Calcium Hypochlorite. Add and dissolve one heaping teaspoon of high-test granular calcium hypochlorite (approximately 1/4 ounce) for each two gallons of water. This mixture will produce a stock chlorine solution of approximately 500 mg/l liter, since the calcium hypochlorite has an available chlorine equal to 70% of its weight. To disinfect water, add the chlorine solution in the ratio of one part of chlorine solution to each 100 parts of water to be treated. This is roughly equal to adding 1 pint (16 oz.) of stock chlorine solution to each 12.5 gallons of water to be disinfected. To remove any objectionable chlorine odor, aerate the water as described above.

(3) Chlorine Tablets. Chlorine tablets containing the necessary dosage for drinking water disinfection can be purchased in a commercially prepared form. These tablets are available from drug and sporting good stores and should be used as stated in the instructions. When instructions are not available, use one tablet for each quart of water to be purified.

b. Iodine.

(1) Tincture of Iodine. Common household iodine from the medicine chest or first aid package may be used to disinfect water. Add 5 drops of 2% United States Pharmaceutical (U.S.P.) tincture of iodine to each quart of clear water. For turbid water add 10 drops and let the solution stand for at least 30 minutes.

(2) Iodine Tablets. Commercially prepared iodine tablets containing the necessary dosage for drinking water disinfection can be purchased at drug and sporting goods stores. They should be used as stated in the instructions. When instructions are not available, use one tablet for each quart of water to be purified.

Water to be used for drinking, cooking, making any prepared drink, or brushing the teeth should be properly disinfected.

Sanitary Regulations

Because public water supplies may be obtained in some areas from ground water, the sanitary regulations for both individual and public water supplies have many technological practices in common. For this reason the character of the regulations for public water supplies as outlined in the appropriate chapter contain also the sanitary regulations that apply to individual water supply systems.

However, if a separate ordinance be preferred, such AN ORDINANCE GOVERNING NON-PUBLIC GROUND-WATER SUPPLY SYSTEMS should provide for regulating the development of ground-water systems and the location, development, construction, or reconstruction of wells; for authorizing the establishment of standards for the location, construction, or reconstruction, installation or operation of wells, appurtenant pumping equipment and ground-water supply systems; for issuing and revoking permits for the construction, or reconstruction of wells, and ground-water supply systems, for installing pumping equipment for wells; for issuing, renewing, and revoking licenses to persons engaged in the business of well-drilling or installation of well pumps; for prescribing duties, responsibilities, and authorities of the health department; and for enforcing the ordinance and setting of penalties for the violation of its provision. The ordinance should also define such terms as health officer, person, ground water, well, ground water supply, domestic purposes and permits.

Suggested Legislation*for Water Well Construction and Pump Installation

[Title should conform to State requirements]

(Be it enacted, etc.)

*Recommended State Legislation and Regulations, U.S. Department of H.E.W., Public Health Service, July 1965.

Section 1. Short Title. This Act shall be known and may be cited as the "(State) Water Well Construction and Pump Installation Act".

Section 2. Findings and Policy. The (State) legislature finds that improperly constructed, operated, maintained, or abandoned water wells and improperly installed pumps and pumping equipment can adversely affect the public health. Consistent with the duty to safeguard the public health of this State, it is declared to be the policy of this State to require that the location, construction, repair, and abandonment of water wells, and the installation and repair of pumps and pumping equipment conform to such reasonable requirements as may be necessary to protect the public health.

Section 3. Definitions. As used in this Act: (a) "Abandoned water well" means a well whose use has been permanently discontinued. Any well shall be deemed abandoned which is in such a state of disrepair that continued use for the purpose of obtaining ground water is impracticable.

(b) "Construction of water wells" means all acts necessary to obtain ground water by wells, including the location and excavation of the well, but excluding the installation of pumps and pumping equipment.

(c) "Department" means the designated agency presently having authority to regulate sanitary practices within the State, usually the State Department of Health.

(d) "Installation of pumps and pumping equipment" means the procedure employed in the placement and preparation for operation of pumps and pumping equipment, including all construction involved in making entrance to the well and establishing seals, but not including repairs, as defined in this Section, to existing installations.

(e) "Municipality" means a city, town, borough, county, parish, district, or other public body created by or pursuant to State law, or any combination thereof acting cooperatively or jointly.

(f) "Pumps" and "pumping equipment" means any equipment or materials utilized or intended for use in withdrawing or obtaining ground water, including, without limitation, seals and tanks, together with fittings and controls.

(g) "Pump installation contractor" means any person, firm, or corporation engaged in the business of installing or repairing pumps and pumping equipment.

(h) "Repair" means any action which results in a breaking or opening of the well seal or replacement of a pump.

(i) "Well" means any excavation that is drilled, cored, bored, washed, driven, dug, jetted, or otherwise constructed when the intended use of such excavation is for the location, acquisition, or artificial recharge of ground water, but such term does not include an excavation made for the purpose of obtaining or for prospecting for oil, natural gas, minerals, or products of mining or quarrying, or for inserting media to repressure oil or natural gas bearing formation or for storing petroleum, natural gas, or other products.[1]

(j) "Water well contractor" means any person, firm, or corporation engaged in the business of constructing water wells.

(k) "Well seal" means an approved arrangement or device used to cap a well or to establish and maintain a junction between the casing or curbing of a well and the piping or equipment installed therein, the purpose or function of which is to prevent pollutants from entering the well at the upper terminal.

1. Some States may wish to include within the coverage of this definition seismological, geophysical, prospecting, observation, or test wells.

Section 4. Scope. No person shall construct, repair, or abandon, or cause to be constructed, repaired, or abandoned, any water well, nor shall any person install, repair, or cause to be installed or repaired, any pump or pumping equipment contrary to the provisions of this Act and applicable rules and regulations, provided that this Act shall not apply to any distribution of water beyond the point of discharge from the storage or pressure tank, or beyond the point of discharge from the pump if no tank be employed, nor to wells used or intended to be used as a source of water supply for municipal water supply systems, nor to any well, pump, or other equipment used temporarily for dewatering purposes.

Section 5. Authority to Adopt Rules, Regulations, and Procedures. The Department shall adopt, and from time to time amend, rules and regulations governing the location, construction, repair, and abandonment of water wells, and the installation, and repair of pumps and pumping equipment, and shall be responsible for the administration of this Act. With respect thereto it shall —

(a) hold public hearings, upon not less than sixty (60) days' prior notice published in one or more newspapers, as may be necessary to assure general circulation throughout the State, in connection with proposed rules and regulations and amendments thereto;[2]

(b) enforce the provisions of this Act and any rules and regulations adopted pursuant thereto;

(c) delegate, at its discretion, to any municipality any of its authority under this Act in the administration of the rules and regulations hereunder;

(d) establish procedures and forms for the submission, review, approval, and rejection of applications, notifications, and reports required under this Act; and

(e) issue such additional regulations, and take such other actions as may be necessary to carry out the provisions of this Act.

Section 6. Prior Permission and Notification. (a) Prior permission shall be obtained from the Department for each of the following:

(1) The construction of any water well;
(2) The abandonment of any water well; and
(3) The first installation of any pump or pumping equipment in any well,

in any geographical area where the Department determines such permission to be reasonably necessary to protect the public health, taking into consideration other applicable State laws, provided that in any area where undue hardship might arise by reason of such requirement, prior permission will not be required.

(b) Notification. The Department shall be notified of any of the following whenever prior permission is not required:

(1) The construction of any water well;
(2) The abandonment of any water well;
(3) The first installation of any pump or pumping equipment in any well; and
(4) Any repair, as defined in this Act, to any water well or pump.

Section 7. Existing Installations. No well or pump installation in existence on the effective date of this Act shall be required to conform to the provisions of Subsection (a) of Section 6 of this Act, or any rules or regulations adopted pursuant thereto; provided, however, that any well now or hereafter abandoned, including any well deemed to have been abandoned, as defined in this Act, shall be brought into compliance with the requirements of this Act and any applicable rules or regulations with respect to abandonment of wells; and further provided,

2. This requirement should be consistent with the general practice for publication requirements in the State and with any State administrative procedure act which may apply.

that any well or pump installation supplying water which is determined by the Department to be a health hazard must comply with the provisions of this Act and applicable rules and regulations within a reasonable time after notification of such determination has been given.

Section 8. Inspections. (a) The Department is authorized to inspect any water well, abandoned water well, or pump installation for any well. Duly authorized representatives of the Department may at reasonable times enter upon, and shall be given access to, any premises for the purpose of such inspection.

(b) Upon the basis of such inspections, if the Department finds applicable laws, rules, or regulations have not been complied with, or that a health hazard exists, the Department shall disapprove the well and/or pump installation. If disapproved, no well or pump installation shall thereafter be used until brought into compliance and any health hazard is eliminated.

(c) Any person aggrieved by the disapproval of a well or pump installation shall be afforded the opportunity of a hearing as provided in Section 13 of this Act.

Section 9. Licenses. Every person who wishes to engage in such business as a water well contractor or pump installation contractor, or both, shall obtain from the Department a license to conduct such business.

(a) The Department may adopt, and from time to time amend, rules and regulations governing applications for water well contractor licenses or pump installation contractor licenses, provided that the Department shall license, as a water well contractor or pump installation contractor, any person properly making application therefor, who is not less than twenty-one (21) years of age, is of good moral character, has knowledge of rules and regulations adopted under this Act, and has had not less than two (2) year's experience in the work for which he is applying for a license; and provided further, that the Department shall prepare an examination which each such applicant must pass in order to qualify for such license.

(b) This Section shall not apply to any person who performs labor or services at the direction and under the personal supervision of a licensed water well contractor or pump installation contractor.

(c) A county, municipality, or other political subdivision of the State engaged in well drilling or pump installing shall be licensed under this Act, but shall be exempt from paying the license fees for the drilling or installing done by regular employees of, and with equipment owned by, the governmental entity.

(d) Any person who was engaged in the business of a water well contractor or pump installation contractor, or both, for a period of two (2) years immediately prior to (date of enactment) shall, upon application made within twelve (12) months of (date of enactment), accompanied by satisfactory proof that he was so engaged, and accompanied by payment of the required fees, be licensed as a water well contractor, pump installation contractor, or both, as provided in Subsection (a) of this Section, without fulfilling the requirement that he pass any examination prescribed pursuant thereto.

(e) Any person whose application for a license to engage in business as a water well contractor or pump installation contractor has been denied, may request, and shall be granted, a hearing in the county where such complainant has his place of business before an appropriate official of [insert the name of the hearing body designated in Section 13 of this Act].

(f) Licenses issued pursuant to this Section are not transferable and shall expire on _____ of each year. A license may be renewed without examination for an ensuing year by making application not later than thirty (30) days after the expiration date and paying the applicable fee. Such application shall have the effect of extending the validity of the current license until a new license is received or the applicant is notified by the Department that it has refused to renew his license. After _____ of each year, a license will be renewed only upon application and payment of the applicable fee plus a penalty of $_____.

(g) Whenever the Department determines that the holder of any license issued pursuant to

this Section has violated any provision of this Act, or any rule or regulation adopted pursuant thereto, the Department is authorized to suspend or revoke any such license. Any Order issued pursuant to this Subsection shall be served upon the license holder pursuant to the provisions of Subsection (a) of Section 12 of this Act. Any such Order shall become effective _____ days after service thereof, unless a written petition requesting hearing, under the procedure provided in Section 13, be filed sooner. Any person aggrieved by any Order issued after such hearing may appeal therefrom in any court of competent jurisdiction as provided by the laws of this State.

(h) No application for a license issued pursuant to this Section may be made within one (1) year after revocation thereof.

Section 10. Exemptions. (a) Where the Department finds that compliance with all requirements of this Act would result in undue hardship, an exemption from any one or more such requirements may be granted by the Department to the extent necessary to ameliorate such undue hardship and to the extent such exemption can be granted without impairing the intent and purpose of this Act.

(b) Nothing in this Act shall prevent a person who has not obtained a license pursuant to Section 9 of this Act from constructing a well or installing a pump on his own or leased property intended for use only in a single family house which is his permanent residence, or intended for use only for farming purposes on his farm, and where the waters to be produced are not intended for use by the public or in any residence other than his own. Such person shall comply with all rules and regulations as to construction of wells and installation of pumps and pumping equipment adopted under this Act.

Section 11. Fees. The following fees are required:
(a) A fee of $_____ shall accompany each application for permission required under Section 6 (a) of this Act.

(b) A fee of $_____ shall accompany each application for a license required under Section 9 of this Act.

Section 12. Enforcement. (a) Whenever the Department has reasonable grounds for believing that there has been a violation of this Act, or any rule or regulation adopted pursuant thereto, the Department shall give written notice to the person or persons alleged to be in violation. Such Notice shall identify the provision of this Act, or regulation issued hereunder, alleged to be violated and the facts alleged to constitute such violation.

(b) Such Notice shall be served in the manner required by law for the service of process upon person in a civil action, and may be accompanied by an Order of the Department requiring described remedial action, which if taken within the time specified in such Order, will effect compliance with the requirements of this Act and regulations issued hereunder. Such Order shall become final unless a request for hearing as provided in Section 13 of this Act be made within _____ days from the date of service of such Order. In lieu of such Order, the Department may require the person or persons named in such Notice to appear at a hearing, at a time and place specified in the Notice.

Section 13. Hearing. [Unless already prescribed in State law, this Section should be used to specify procedures for administrative hearing.]

Section 14. Judicial Review. [Unless already prescribed in State law, this Section should be used to specify procedures for judicial review.]

Section 15. Penalties. Any person who violates any provision of this Act, or regulations issued hereunder, or Order pursuant hereto, shall be subject to a penalty of $_____. Every day, or any part thereof, in which such violation occurs shall constitute a separate violation.

Section 16. Conflict with Other Laws. The provisions of any law, or regulation of any municipality establishing standards affording greater protection to the public health or safety, shall prevail within the jurisdiction of such municipality over the provisions of this Act and regulations adopted hereunder.

Section 17. Severability. [Insert severability clause]

Section 18. Effective Date. [Insert effective date]

Chapter XII

Swimming Pools and Public Bathing Places

All sanitary problems relating to water supplies are the province of the public health engineer and the sanitarian. This includes the sanitary problems relating to public swimming pools and bathing places. The designing, construction, alteration, and functioning of the physical plant of swimming pools which includes the filters, tanks, piping, pumps, chlorinators, the pool plumbing, electrical installations, heaters, ventilators, pool bottom, walls, gutters, runways, dressing rooms, visitors' galleries, showers, toilets, lavatories, and the like are engineering problems. The sanitarian, however, has an important part to play in relation to this set up. He makes inspections of dressing rooms, showers, toilets, and lavatories. He tests the temperature of the water and atmosphere, the chlorine content of the water, the ventilation and lighting, and examines the records of the operator. He observes the pool load, the safety devices, and the safety personnel. He collects samples of water, carries on research projects, makes sanitary surveys of outdoor bathing places, and inspects the mechanical apparatus for cross connections, back-flow connections, and other defects in collaboration with and as an assistant to the engineer. In order to do this, the sanitarian must understand the principles upon which swimming pool and bath place sanitation and safety are based. Nowhere have these principles been better stated than in the recommendations of the Joint Committee on Bathing Places of the Conference of State Sanitary Engineers and the Engineering Section of the American Public Health Association. The 1948 recommendations, as amended in 1950, and again amended in 1957, are presented in full below with the addition of an electrical Safety Code for electrical installations for swimming pools and bathing places.

1. Classification of Bathing Places

A. The term "bathing place" as used in this report includes all bodies of water sufficiently deep for complete immersion of the body and used collectively by numbers of persons for swimming or recreative bathing together with the shores, buildings, equipment, and appurtenances pertaining to such bathing places. It does not include public or semi-public baths, where the main object is the cleansing of the body or the practice of the healing art, unless such baths contain pools or tanks used collectively by a number of individuals.

B. Bathing places may be divided into three classes:

1. Natural outdoor ponds, rivers, tidal waters, etc.
2. Outdoor pools which are partly artificial and partly natural in character.
3. Pools, outdoor or indoor, which are entirely of artificial construction.

Natural ponds and rivers are necessarily dependent upon natural flow or upon temperature, wind, and wave action for circulation of the water. Artificial and partly artificial pools may be divided into four classes according to the method by which water cleanliness is obtained:

a. Fill and draw pools where cleanliness of water is maintained by complete removal and replacement of the water at periodic intervals.

b. Large semi-artificial pools in which the water cleanliness is maintained by natural flow or circulation in a manner corresponding to a natural pond or lake.

c. Flowing-through pools where cleanliness is maintained by circulation of water through the pool from some natural or developed source, but where the outflowing water is wasted.

d. Recirculation pools in which circulation of the water is maintained through the pool by pumps, the water drawn from the pool being clarified by filtration before being returned.

2. General Principles of Bathing Place Sanitation

A. In the control of swimming pool and bathing place sanitation certain broad principles apply to all classes of public bathing places.

B. The committee is of the opinion that all public bathing places both natural and artificial should be under the sanitary control of the public health authorities.

C. In the opinion of the committee the same standards of cleanliness and bacterial purity of the water and the same precautions against the possible spread of disease should apply at

both indoor and outdoor swimming pools.

D. The requirements should be the same for all artificial and semi-artificial pools whether located indoors or outdoors, so far as the features of design and equipment apply to maintenance of cleanliness of the pool and of the water with which it is filled.

E. There is a tendency for some families to install small fill-and-draw swimming pools for the use of the family and possibly some neighbors or friends. Such pools should not be operated as large bathtubs; users should take precleansing baths and use the toilet prior to entering the pool. Chlorine disinfection and procedures for chlorine residual testing should be established. Water should be changed frequently to improve water appearance and clarity. The use of fill-and-draw pools is not recommended by the committee but rather the committee recommends provision of recirculation, filtration, and disinfection facilities.

F. Sanitary drinking fountains with a supply of safe potable water should be installed at all bathing places. The installation and construction of such fountains should conform to the recommendations of the American Public Health Association. (See 1933-1934 A.P.H.A. Year Book.) The common use of towels, drinking cups, combs, hair brushes, or other toilet articles should be strictly prohibited.

3. Bathing Beaches
This subject is discussed in Sections 29 to 38.

Swimming Pools

4. Location and Layout of Pools

A. The location of an outdoor pool will be governed largely by local conditions; and arrangement of dressing rooms, etc., can be made to conform to the sanitary requirements. In locating an indoor pool careful study must be given to architectural and engineering features in order that the proper layout may be obtained.

B. The layout or arrangement of entrances and exits of the pool room in relation to dressing rooms, showers, and toilets must be such as to provide proper routing of bathers. Coming from the dressing room a bather should be required to pass the toilets, and go through the shower room before arriving at the pool entrance.

C. At pools used simultaneously by both sexes, separate entrances and exits should be provided for men and women. There should be no connection between men's and women's quarters.

D. Entrances and exits must be located at shallow water portion of the pool.

E. If the pool is to be of recirculation type, ample room must be provided for filters and other units. All recirculation piping, inlet and outlet valves, etc., must be located where they will be readily accessible.

F. At pools where chlorine disinfection is to be used, it is recommended that the chlorine apparatus be so located as to be readily observed, and the location should be such that there be a minimum opportunity for leakage of gas into equipment rooms or areas where persons gather. An exhaust fan for ventilation is a good safeguard. Precautions with chlorine equipment installation and maintenance are discussed in Section 18-B.

G. Off-season protection in the case of outdoor pools, which is required during the major portion of the year is important. In cold winter climates, protection to the pool structures against damage by ice should be considered. All pipe lines should pitch to low points and be provided with drain cleanout plugs. Equipment such as motors which might be damaged if exposed to possible flooding by high water from failure of sump pump, should be removed or elevated to a point where protection will be afforded.

5. Design and Construction Features

A. Material -- Any material which will provide a tight tank with smooth and easily cleaned surfaces may be used for artificial swimming pools. (See also paragraph 5-I.)

B. Details of Design -- The details of design in so far as they relate to strength of material waterproofing, etc., are essentially the same as in design of other tanks of similar size and

shape and are, therefore, omitted from this report.

In the design of a new pool, provision should always be made for complete circulation of water through all parts of the pool during the bathing period. Without proper circulation it is difficult or impossible to maintain good sanitary conditions at all times, even though the pool be completely emptied, cleaned, and refilled each day. The installation of new fill and draw pools cannot be recommended.

C. Shape -- Indoor pools should be of rectangular shape with deep water at or near one end and shallow water at the other. Small outdoor pools should be of the same general design as indoor pools. The best shape for large outdoor pools depends largely on the size and on local conditions.

D. Dimensions -- Length of pool should be not less than 60 feet and width should ordinarily be some multiple of 5, 6, or 7 feet. For swimming records, a straightaway course of at least 60 feet with 5 or 6 feet lanes is required. In strictly competitive pools, the lanes should be a minimum of 7 feet.

E. Depth of Water -- The minimum depth of water in the deep portion of any public pool should be not less than 6 feet. Water areas shallower than 3 feet should usually be confined to separate wading pools.

F. Proportion: Deep and Shallow -- Some authorities recommend that the area of shallow water, 5 feet or less in depth, should be 80 percent or more of the total area of large outdoor pools. Such proportioning must be considered in relation to the pool volume, the bathing load, the recirculation or flowing through purification system, etc. The committee has insufficient information on this point to warrant any recommendation at the present time.

G. Slope of Bottom -- The slope of the bottom of any part of a pool where the water is less than 5.5 feet deep must not be more than 1 foot in each 15 feet. There should be no sudden changes of slope within the area where water depth is less than 5.5 feet. The reason for this recommendation is that with a shallower breakpoint in slope, such as at 4 feet, children over 4 feet in height who are unable to swim may suddenly find themselves in the steep slope and lose their footing. It is the judgment of the majority of the committee that the recommendation should stand in the interest of safety despite some proposed modifications. California has a somewhat less rigid standard calling for a slope of not more than 1 foot in each 12 feet up to a depth of not more than 5.0 feet which they believe to be satisfactory.

H. Side Walls -- The side and end walls of all artificial and semi-artificial pools should be vertical. Sloping side walls are dangerous and cannot easily be kept clean. Some authorities approve safety ledges on vertical walls in the deep portion of a pool which may be 4 to 6 inches wide at a depth of 4 feet 6 inches below the water surface and may slope 1/2 inch toward the pool.

I. Pool Lining -- Including bottom and sides up to runways, lining must be of white or light color material and present a smooth finished surface without cracks or joints. All corners must be rounded. Tile or glazed brick lining is recommended for all indoor pools and for small outdoor pools. White cement smoothly finished is satisfactory for large outdoor pools. Dirt does not show on asphalt or other similar dark material, and such materials are not suitable for pool lining. Sand or earth bottoms cannot be kept clean and are not recommended for pools.

J. Markings --It is recommended that swimming lanes be marked on the bottom with dark colored material of the same kind as pool lining. The outlet of the pool should also be plainly marked by a black or dark colored circle, unless outlet grating be of a conspicuous coloring. The depth of water at the deepest point and at the 5 foot point should be conspicuously marked on both sides of a pool with deep water at one end. Markings showing depths in 1 foot increments are desirable. In large pools with deep water only in the middle, the 3 and 5 foot depth lines should be conspicuously marked on the bottom, and portions of the area may also be designated by surface floats.

6. Proportioning Pool Area to Expected Load

A. In the design of an artificial pool, due allowance must be made for the number of bathers who may be expected at the time of maximum use. In computing the area which must be provided, it is recommended that the pool be divided into three zones, and the area of each computed separately.

B. From the data collected by the committee for its fifth report, it was the concensus tha[t]

an area extending 10 feet from the extremity of a diving board or tower should be considered as reserved for divers, and that not more than two or three persons should be permitted in the water in this area at one time while diving is in progress. About three times that number will be on the shore or diving platform awaiting their turn to dive. Twelve persons be therefore the maximum number which may be permitted for the area within 10 foot radius of each diving board or platform.

C. It was the consensus of swimming pool operators that the space required by a swimmer might fairly be expressed as five-fourths the square of his height and that on an average two-thirds of the swimmers present would be in the pool at the same time. On this basis the average space requirement for an adult swimmer is 36 square feet and, allowing for one-third of swimmers on the shore, an average of 24 square feet should be provided for each swimmer who may be expected to be present at time of maximum load.

D. In computing the area to be provided for persons who do not swim, we must take into consideration the character of the pool. At indoor pools and small outdoor pools, this area should probably be included with the swimming area and the crowding limit computed as such. At large pools where a considerable proportion of the water is shallow water, it is sometimes assumed that 50 percent of the non-swimmers would be on shore although 75 percent is sometimes more nearly correct and may be used for many pools. The average space allowance for each non-swimmer in the water is approximately one-half that of the swimmer in deep water. Combining these factors, an allowance of 10 square feet per bather should be allowed for this portion of the pool.

7. Inlets and Outlets

A. All pools should be provided with an outlet at the deepest point of sufficient size to permit the pool to be completely drained in 4 hours or less. Outlet openings of the grating in the floor of the pool should be at least four times the area of the discharge pipe to reduce suction currents. Openings must be covered with a proper grating which is not readily removable by bathers.

B. In rectangular pools with deep water at or near one end, multiple outlets should be provided where the width of the pool is more than 20 feet. In such cases outlets should be spaced not more than 20 feet apart, nor more than 10 feet from side walls.

C. Proper pipe connections must be provided in recirculation pools to permit water being drained to the sewer as well as to recirculation pumps. No direct connections to sewers shall be permitted, and all pool drains to sewers shall be broken at a point where any sewage which may back up from the sewer will overflow to waste instead of being permitted to reach the pool. Pumping of pool drainage to an elevation above any possible sewer backing may in some cases be needed.

D. Inlets for fresh or repurified water should be located to produce as far as possible uniform circulation of water and the maintenance of a uniform chlorine residual throughout the entire pool without existence of dead spots. Design should be such as to avoid the need for operating with extremely high concentrations of chlorine at one or more points in the pool to introduce the necessary amount of chemical. In semi-artificial pools of irregular shape a careful study should be made of probable circulation currents, and inlets should be located and spaced to provide as complete circulation as possible. Inlets from the circulation system should be submerged to reduce escape of chlorine odors. Where water from the public water system is added to the pool, cross-connections between the public water system and the swimming pool water should be eliminated by pumping make-up water from a pump suction well or admitting water to the pool above the over-flow elevation of the pool. It is recognized that the avoidance of cross-connections in this manner may require the installation of a separate heater on the line supplying make-up water, particularly where large amounts of make-up water are added.

E. Where the distance across the shallow portion of the pool is more than 15 feet, multiple inlets must be provided, so spaced that each inlet will serve a linear distance of not more than 15 feet. At spoon-shaped rectangular pools where the outlets are located more than 5 feet from the end wall, inlets should be placed at both ends of the pool. At large pools with outlets near the center, inlets should be placed at the specified intervals entirely around the perimeter of the pool.

F. Each inlet should be designed as an orifice subject to adjustment or at least must be provided with an individual gate valve so as to proportion the volume of water required at the

particular point to obtain the best circulation.

G. In a few cases, pools have been designed for fresh water or repurified water to enter at the deep point and overflow through outlets or overflow gutters in the shallow portion. It is believed there may be some advantage in having flow through the pool in this direction, thus permitting floating matters and dirtier water from the more crowded shallow area to be carried off more rapidly. The committee suggests that in designing piping systems for recirculation or flowing-through pools, connections be provided so that flow through the pool may be in the direction which experiments may prove most desirable. It is also suggested that the question of having overflow gutters serve as overflows and outlets in recirculation or flowing-through systems be studied carefully, as it appears that such design may have certain material advantages, although at the same time some of the flow should probably at all times pass out through the bottom of the pool to avoid dead spots and facilitate removal of sediment.

H. Where overflow drains are discharged to a closed recirculation system, they may be piped to a balance tank which in turn is connected to the pump section, with the tank so designed that surface oils and accumulations may be discharged to waste. Incidentally, a balancing tank whether connected to receive overflow gutter discharge or placed in any recirculation system has two other useful purposes:

(1) It provides an excellent place for introduction of chemicals into the system;

(2) It may be used as a surge tank to overcome the desire for a cross-connection with the public water supply. It is recommended that consideration be given to installation of balancing tanks in connection with pool recirculation systems.

I. In recent years one national organization has installed a number of so-called "water-level deck type" swimming pools which differ from the conventional pool in that the water level is maintained about flush with the peripheral overflow around the entire edge of the pool and there are no overflow gutters around the pool. Water is frequently flushed over the edge of the sides and ends of the pool onto a floor which is sloped toward deck drains which are spaced at about 15 foot intervals and covered with grating. Nonslip tile is used. Scum is carried off to the drains. Experience has seemed to be that it is relatively easy for bathers to rest their hands on the edge of the pool and kick their feet so there has been no proved safety hazard, although one state has recommended a rim for a handhold. At most of these pools, two built-in cuspidors have been provided at the end walls which have seemed to be satisfactory with proper supervision. There must, of course, be a balancing tank to maintain proper pool level. If there were bad settling of a pool of this type after construction, serious operating difficulties might arise due to the pool edges being out of level.

8. Overflow Gutters

A. Overflow gutters should extend completely around the pool. The design of overflow gutters should be such that matters entering them will not be washed out by a sudden surge of entering water, and that danger of bathers catching arms or feet in them be reduced to a minimum. The edge of an overflow gutter should be designed to serve as a hand hold for bathers. Gutters should, therefore, be sufficiently deep that bathers' fingers will not reach to the bottom. Sufficient opening must be provided to permit mechanical cleaning of the gutters.

B. Drainage outlets should be provided at least every 15 feet and the gutter bottom should pitch slightly to these outlets. Outlet pipes 2 1/2 inches in diameter with outlets covered by gratings discharging into pipes of larger size are desirable. Drainage from overflow gutters may be discharged to sewers (without direct connection), or to suction of recirculation pumps, or to a balancing tank as pointed out in Section 7-H. Arrangements for either utilizing overflow water or wasting it, as desired, are both advised.

C. Open, roll-over, or semi-recessed types of overflows, easily accessible for cleaning and inspection, should be used.

D. Recently many installations of a recirculating surface skimmer have been made, apparently mainly to reduce costs, by eliminating overflow gutters. Limited operating experience is available but it would appear that this type of equipment would have its most usefulness in connection with small pools such as in country clubs, hotels, etc., with limited bathing loads. The committee awaits more data on operating experience and continues to recommend overflow gutters for large pools.

9. Steps, Ladders, and Step Holes

A. Steps or stairways for entering and leaving the pool should be of such construction as to minimize danger of accidents. Ladders or stairways should be located at one or both sides of

the deep end of the pool. If the distance from the bottom of the pool to runway is more than 2 feet, a ladder or steps should also be placed at the shallow end of the pool. Treads of ladders or steps should be of non-slip material.

B. In some pools ladders have been replaced by step holes inserted in the pool wall. If step holes are provided, they should be of such design that they may be readily cleaned and be provided with drains into the pool to prevent accumulation of dirt.

C. Stairs, ladders, or step holes should have a handrail on either side at the top leading out over the runway. Stairs should not project into the pool. If stairs are desired, the stairway should be recessed into the wall and the runway of pool.

10. Runways or Sidewalks

A. Runways not less than 4 and preferably at least 8 to 10 feet wide should extend entirely around the pool. Runway floors should have a slope of about 1/4 inch to the foot, should be smooth and easily cleaned, but should be of non-slip construction as far as possible. The edge of the pool runway must be of non-slip construction for a width of at least 1 foot. The edge of the pool at its junction with the runways should be rounded. At indoor pools, unless runways are very wide, handrails on the outside wall are desirable.

B. In pools where overflow troughs are connected into recirculation system, the runway drainage should not slope toward the troughs. It is suggested that one floor drain be provided for each 100 square feet of floor area.

C. Some sanitary authorities also require a raised edge 2 inches or more in height between the pool and runways. Such a raised edge may lead to accidents by bathers tripping thereon and cannot be recommended for indoor pools. At outdoor pools a raised edge forms a barrier between pool and runway and permits the use of greater hose pressure for flushing. If installed for this purpose, such an edge should be not less than 1 foot wide and at least 6 inches high in order that danger of accidental tripping may be reduced as much as possible.

D. High, tight walls should encircle the pool outside the runways. Walls or fences encircling pools should be placed directly against or adjacent to pool walkway or runway. Some outdoor pools have been constructed with areas of sand or grass and shrubbery just outside the runways. The practice is objectionable as it leads to tracking of much dirt into the pool. Trees and shrubbery overhanging or adjacent to the pool or runways are also objectionable and may cause unnecessary dirt in the pool.

11. Visitors' Galleries

There must be an absolute separation of the space used by spectators and that used by bathers. There should be no means by which bathers can enter space reserved for spectators or vice versa. Visitors' quarters must have a separate entrance. Galleries for spectators should not overhang any portion of the pool surface. Floor and foot rail of the gallery should be of tight construction to prevent dirt tracked in from getting into the pool. Gallery floor should slope to a drain and should in no case be allowed to drain upon the area used exclusively by bathers. A curb or other provision should be used to prevent litter and dirt from being kicked or scuffed by spectators into the pool or pool area. Seats in galleries should be of non-absorbent construction to permit washing.

12. Dressing Rooms

A. Bathhouses to be used simultaneously by both men and women should have two parts, one for each sex, entirely separated by tight partitions. Screens should be placed at entrances and exits of dressing rooms to break line of sight.

B. Floors of all dressing rooms and locker rooms should be of smooth finished material, impervious to moisture, with no open cracks or joints. All floors should have a pitch of about 1/4 inch to the foot and should slope to a proper drain to permit washing down with a hose. All junctions of the floors with side walls and partitions should be finished with rounded joints. All

walk areas used by patrons in bare feet should so far as possible be of non-slip construction.

C. Walls and partitions of all dressing rooms and locker rooms should be of smooth, impervious material, without open cracks or joints. If walls of wood or similar material be used, all cracks and joints should be filled and the surface kept finished with paint or other sanitary waterproof coating. Partitions between dressing compartments should terminate not less than 4 inches above the floor to permit flushing of the entire floor area. Some authorities prefer 12 to 18 inches. Hose connections should be provided at frequent intervals for cleaning bath house facilities and pool area.

D. All furniture used in dressing rooms should be of simple character and of easily washable material. Lockers where provided should be of vermin proof construction with tight joints. All lockers should be properly ventilated.

E. All dressing rooms and appurtenances must be kept clean at all times. The use of an insecticide spray for lockers and of a disinfectant on floors, walls, and seats at frequent intervals is recommended. A 0.3 to 0.6 percent solution of available chlorine is suggested as a disinfectant, to prevent the spread of foot infections. Foot tubs without proper disinfectant solution should be prohibited.

13. Showers, Toilets, Lavatories

A. Adequate shower bath facilities with hot and cold water should be provided at all artificial pools. Liquid or powdered soap in suitable dispensing equipment should be considered as a necessary part of each shower unit. The minimum number of showers provided should be in the proportion of one for each 40 bathers expected at time of maximum load, in the case of continuous bathing. For bathing by classes, as at schools, the number of showers may be taken as one-third the number of pupils in the maximum class. Showers in the nude are to be encouraged to promote cleanliness.

B. Shower baths should be of such design that a proper mixture of hot and cold water may be obtained without danger of scalding the bather.

C. Adequate and proper toilet facilities for each sex must be provided at all pools and beach bathhouses. The minimum number should be one toilet for each 40 women and one toilet and one urinal for each 60 men. Urinals should be of a type that will not cause splashing of urine upon legs and feet of bathers. Urinals and toilets should be so located that bathers will use them before entering the showers on their way to the swimming pool.

D. Water flush toilets should be provided wherever possible. All toilets must be properly maintained.

E. Lavatories located adjacent to toilets should be provided at all swimming pools in the proportion of one bowl to each 60 persons using the pool at time of maximum load.

F. The use of solutions containing 0.3 to 0.6 percent of available chlorine has been found of value as a foot wash for the prevention of so-called "athlete's foot". At many swimming pools, bathers are required to rinse their feet in such a solution before entering the pools. Many authorities consider it preferable to place the foot bath at the exit from the showers to the dressing rooms so as to spread the chlorine over the dressing room floor and increase the time of contact. In some cases, 15 percent sodium thiosulfate solutions have been used with success as a preventive foot wash but in one large city poor results with this chemical have been reported. One reason attributed to lack of success with sodium thiosulfate is failure to employ freshly made up solutions using a good grade of chemical. Sodium thiosulfate is a reducing agent and will reduce the available chlorine in the pool if bathers use it in a foot bath before entering the pool so that its use should be limited to bathers leaving the pool.

Another interesting development is a report from Detroit, Mich., that Dr. Loren Schaffer has conducted successful experiments with a 10 percent by weight salt NaCl solution for control of "athlete's foot." More data on this treatment will be awaited.

Foot baths in themselves are not the only means of attempting control of "athlete's foot." In fact, some authorities do not favor their use because of difficulties in securing effective control of the disinfectant strength. General sanitation and floor cleanliness are of even more importance than foot baths. Bathhouse floors and runways should be so constructed that they will drain readily, and it is imperative that they be scrubbed daily. Insufficient attention is undoubtedly paid to proper ventilation of dressing room floors, with the result that in many bathhouses dry floors, which are of considerable aid in the control of "athlete's foot," are never encountered. Some authorities look with favor upon open court dressing rooms for outdoor pools, with only the booths covered. Netting is frequently placed over the open courts to keep birds out of the dressing booths.

14. Lighting, Ventilation, Heating

A. A complete system of artificial lighting must be provided for all pools, bathing beaches, bathhouses, and dressing rooms that are to be used at night.

B. Lighting fixtures must be of such number and design as to light all parts of the swimming pool and the water therein. Underwater pool lighting is meeting increased favor in that it tends to add to the attractiveness of the pool. Such lights must be so installed as to create no hazard to bathers.

C. Arrangement and design of lights must be such that life guards may see clearly every part of the bathing waters at a beach or pool, and all spring boards, towers, floats, and other appurtenances, without being blinded by the light.

D. Indoor pools should be so located that they may be lighted during the day by windows on at least one side or by skylight. The window or skylight area should not be less than one-half the area of the pool including the runways.

E. All indoor pools and all bathhouses, dressing rooms, shower rooms, and toilets at both indoor and outdoor pools and beaches, must be properly ventilated. Ventilation of indoor pool rooms must be so designed that direct draft will not blow on bathers.

F. All heating units shall be isolated or protected from contact with bathers to prevent injury. The heating units in dressing rooms, shower rooms, and toilets shall be capable of maintaining a temperature between 70° F. and 75°F. The pool room heating units shall be capable of maintaining a temperature between 75°F. and 82°F. Thermostatic control of the temperature is desirable.

G. The acoustical property of pool rooms has not received the attention it deserves. Designs and materials of construction, which will prevent reverberations of sound that result in confused noises, should be used. It is very important that an instructor's voice or a call for help may be clearly distinguished.

15. Recirculation System

A. The System -- The recirculation system consists of the pumps, hair catcher, and filters together with all necessary pipe connections to the inlets and outlets of the pool. The water heater, the chlorinator and the suction cleaner are also usually installed on or connected with the recirculation system and may be considered as integral parts thereof. This entire system and all its component parts should be designed to provide the required volume of recirculation water as specified in section 16-B with a minimum of frictional resistance. Filtration and disinfection are discussed separately in subsequent chapters. The requirements for other parts of this system are as follows:

B. Pumps -- Centrifugal pumps are preferable for swimming pool circulation, although plunger pumps are sometimes used. Electric drive is also preferable. When pipe lines from suction cleaner lead to pump suction, a pump which will develop good vacuum must be used. Pump and piping should be of such capacity as to provide for a turnover of pool water in at least 8 hours or a turnover ratio of 3. Many authorities favor a turnover in 6 hours or a turnover ratio of 4. When pressure filters are used, pumps must be designed to pass the required volume under the maximum head which may develop in the filters. When less than four pressure filters are used, shutting off of one filter and backwashing with the same recirculation pump, discharging wash water through the remaining filters to the filter to be washed, may result in reducing the wash water rate below a range of 10 to 15 gallons per square foot per minute; this range is usually considered desirable. Sometimes this has led to the provision of a special wash water pump of adequate capacity to provide higher wash water rates; such a provision is rather infre-

quently made and no serious operating difficulties have been called to the attention of the committee due to the lack of a special pump. If filters and pumps are located at an elevation higher than the water line of the pool, a check valve must be placed on the pump suction.

C. Hair Catcher -- The recirculation system should include a strainer to prevent hair, lint, etc., from reaching the filters. The best type of hair catcher consists of a metal chamber containing a removable cylindrical strainer, so arranged that the water passes through the strainer from the outside. The strainer should be of non-corrosive material with openings not more than 1/8 inch across. A slotted strainer is more easily cleaned than one which is perforated. The area of strainer openings should be at least ten times the area of the water inlets. Hair traps should be so constructed that they can be quickly taken down for cleaning by loosening two or three wing nuts. Proper valves should be provided to prevent flow of water through the strainer while cleaning. One state has reported success with the use of a fine screen set across the balancing tank as a substitute for the usual type of hair catcher.

D. Water Heater -- In northern climates some method of heating the water is essential for indoor pools. Blowing steam directly into the pool as is practiced in some instances or heating coils placed directly in the pool are not recommended. A heater designed to heat all or part of the circulation is preferable. In designing a heater, ample surface for heat interchange must be provided. Such a heater may be designed for use with steam or hot water. Automatic thermal control is desirable. Provision should be made for easy removal of the heater parts for cleaning.

E. Suction Cleaner -- In the opinion of the committee a satisfactory method of removing the dirt, hair, etc., settling on the bottom of a pool is by means of a suction cleaner. With careful operation a brush may also be used successfully. As suction cleaners are commonly operated by the circulation pumps, they may be cleaned as an adjunct to the recirculation system. When a suction cleaner is to be operated by the recirculation pump, a gate with graduated stem or other registering device should be provided for throttling the flow from the pool outlet to permit the pump to operate at maximum efficiency when the suction cleaner is in use. Fixed pipe connections at least 8 inches below the water surface for attachment of suction cleaner to pump suction should be of ample size to reduce friction to a minimum, and the cleaner and all removable connections should be designed to provide a maximum velocity at the suction nozzle. Some use of portable suction cleaners has been reported.

F. Piping System -- The piping system should be properly designed to reduce friction losses to a minimum. Pipe capacities should generally be at least double the theoretical value. Flange joints or unions should be inserted at intervals to permit any part of the system to be taken down quickly for cleaning or repairs. A sump and blow-off should be provided at the lowest part of the system to permit removal of any accumulating iron rust. Openings should be provided for insertion of gauges to permit vacuum or pump suction and pressure at discharge to be determined, should a study of the recirculation system be desirable. A rate-of-flow meter or indicator should be provided for checking the actual volume of water passing through the system under working conditions. Outlets should be provided for purposes of laboratory tests. Other requirements for piping are discussed under the heading "Inlets and Outlets." It is recommended that piping used for different purposes be painted distinguishing colors.

G. Testing the System -- After the recirculation system has been installed and the various units have been tuned up, a test of the hydraulic properties of the entire system and of each integral unit should be made. In such a test the velocity in the piping system at various points, the discharge capacity of each filter and each pump, the velocity and volume of wash water in each filter, and the rate of discharge at each pool inlet should be determined under actual working conditions with the pool at normal working level. The full data of this test should be a matter of permanent record for future comparison. A similar test repeated at least once a year is desirable.

H. Thermometers -- At indoor pools a fixed thermometer shall be placed on the recirculation line beyond the heater and another near the outlet of the pool. At outdoor pools one thermometer is usually sufficient. Thermometers shall be accessible and have a type of scale that is easily interpreted.

I. Cross-connections -- The avoidance of cross-connections on the pool piping system whereby pool water may under some conditions enter a potable water supply system which is connected either for admission of new water to the pool or for washing of filters is discussed in sections 7-D and 17-E. The possibility of polluting pool water from sewer connections is discussed in

section 7-C. The dangers of cross-connections are also stressed under this heading. Attention is called to occasional cross-connections found between a potable water supply source and swimming pools through the piping to injectors used for applying disinfectants and the danger of reversals of usual flow direction must be guarded against.

16. Proportioning the Water Interchange for Recirculation and Flowing-through Pools

A. In a recirculation or flowing-through pool in which the dirty or used water is continually being withdrawn and replaced by fresh or filtered water, purification of the pool water proceeds by consecutive dilution. The first portion withdrawn from the pool will all be dirty water, but owing to the constant admixture of entering clean water with the dirty water remaining in the pool, each succeeding portion of water withdrawn will consist of a decreasing proportion of dirty water mixed with an increasing proportion of clean water. In proportioning the rate at which fresh water should be added to a flowing-through pool, or the capacity of pumps, filters, etc., for a recirculation pool, this law must be taken into consideration. Flowing-through pools are not recommended by the committee but dilution factors are discussed.

B. Gage and Bidwell have worked out the law of purification by consecutive dilution as applied to recirculation and flowing-through pools and this is described by them as follows:

It is proposed that the rate of water interchange in a recirculation or flowing-through pool be expressed as the ratio of the volume of clean water entering the pool in 24 hours to the total pool volume. For convenience this ratio may be called the "Turnover" rate or "T" of the pool purification system. For example T = 1 when the volume of water recirculated in 24 hours is the same as the pool volume, T = 2 when the water circulated in 24 hours is twice the pool volume, etc.

It can readily be demonstrated by computation and by experiment that seven turn-overs are required to effect a removal of 99.9 percent of the dirt present in the water of the pool when recirculation was started. At the end of the first turn-over the purification will be about 63 percent, after two turn-overs about 86 percent, at the end of three turnovers about 95 percent, after four turn-overs about 98 percent, after five turn-overs 99.3 percent, after six turn-overs 99.7 percent. To accomplish a purification of 99.99 percent, ten turn-overs will be required.

If the pool be used regularly by bathers, further increments of dirt will be introduced into the water daily, and the removal of each successive daily increment will proceed according to the law. The result of the addition of such daily increments will be an increasing accumulation of dirt in the water up to a certain point, after which the dirt content of the pool water will remain practically constant, subject only to the fluctuations caused by the variations in the daily bathing load. The amount of this accumulation and the time required for the pool water to reach a condition of equilibrium depend upon the rate of turn-over of the pool by the flowing-through or by the recirculation system, and in the latter system, is also dependent upon the efficiency of the filters.

Assuming a daily increment of dirt equal to that in the pool at the start and a filter efficiency of 100 percent, with a daily turn-over (T = 1), equilibrium will be reached at the end of the ninth day when the accumulated dirt in the pool will be equivalent to about 58 percent of the amount present when recirculation and daily bathing was started. With two turn-overs per day (T = 2), equilibrium will be obtained in four days with a dirt load of about 16 percent, with T = 3, a balanced load of about 5 percent will be obtained on the third day, and with T = 4, a balanced load of about 2 percent will be obtained at the end of the second day. On the other hand, if the recirculation system be so small that it required two days for each turn-over, accumulation of dirt in the pool will continue for about nineteen days and the dirt load carried in the pool thereafter will be about 155 percent of the amount present at the start.

It is evident, therefore, that if clean water is to be maintained, the recirculation or flowing-through system must be designed to provide a turn-over ratio of at least two, although to insure satisfactory conditions, the turn-over ratio should be at least three. It is also evident that the recirculation of flowing-through system should be kept in operation continuously and that the filter should be operated in the most efficient manner. If the filters have an efficiency of only 50 percent, or the recirculation system is operated only half the time, the effect will be the same as though the recirculation system were only half size.

17. Filtration

A. Rapid gravity filters and pressure filters are used in swimming pool repurification

system. More than 80 percent of the recirculation pools in this country are equipped with pressure filters and for indoor pools and small pools where space is limited, this type of filter is to be preferred unless the water be very hard. For large outdoor pools the gravity type rapid filter is suitable and is preferred by some sanitary authorities. Where the water is very hard and cementation of the filter medium is likely to occur,the open type of filter is to be preferred.

B. Batteries of four or more filters arranged in parallel are preferable to single unit,in order to obtain a proper wash water rate where the same pump is used for recirculation and washing. If less than four filters be used, a special wash water pump may be considered desirable but as mentioned in Section 15-B., it is admitted that such a provision is rather infrequently made and no serious operating difficulties have been called to the attention of the committee due to the lack of a special pump.

C. Filtering material should consist of at least 36 inches in depth of suitable grades of screened sharp filter sand or crushed quartz and filter gravel. Experience has shown that satisfactory results are secured when the effective size of the sand is about 0.4 to 0.5 mm. with a uniformity coefficient not exceeding 1.75. Sand should be washed free from clay, organic matter, and soluble material. There should be at least 18 inches of free board above the surface of the filter material to the overflow troughs or pipes of rapid filters to permit proper washing without loss of filter sand. There has been some reported successful use of filtering media other than sand such as anthracite (grandular coal) and calcite (granular calcium carbonate).

D. In designing a filter system for a swimming pool,the rate of rapid filters should not exceed 3 gallons per minute per square foot of surface area. Rate controllers are not usually installed on the rapid filters used for small swimming pools because of the considerable increase in cost. Filters for large pools (100,000 gallons or more) should be equipped with rate controllers and such control is desirable on smaller installations. The filter system should be designed on the basis of a turn-over ratio of at least three. Some state health departments require a turnover ratio of at least four.

E. Rapid filters of open gravity type must be equipped with loss of head gauges. Pressure filters must be equipped with pressure gauges on both the inlet pipe and the outlet pipe for determination of loss of head or back pressure in the filter medium. Pressure filters should have a proper sight glass installed on the waste discharge pipe by which the operator may watch the progress of filter washing. Such glass should be readily removable for cleaning, and should be kept clean. Each pressure filter should be provided with an adequate air release, connected to the filter shell at or near the high point. The arrangement and number of valves and interconnecting piping, or "valve nest," for necessary and convenient operation of rapid filters is fairly well standardized, and a discussion thereof may be omitted. It is usually desirable to have four filter units so that one unit can be cut out of use and washed with the filtered pool water. With four filter units in ordinary use, one filter can be washed with the use of the recirculation pump at nearly four times the ordinary filtering rate. If washing with the recirculation pump be not feasible, one alternate method is to install a wash water pump of higher capacity, as has been mentioned previously, and a suction well or small elevated feed tank, supplied with water from the public water system, can be used to supply water to the pump. Over-rim inlets from the public water system to the well or tank shall be used to avoid cross-connections. Valved cross-connections whereby water from a potable water supply may be admitted directly to the recirculation system for the purpose of filter washing may permit pool water to gain access to the potable water supply because of leaking valves or suddenly lowered pressures. They shall not be permitted in the case of new swimming pools, and every reasonable effort shall be made to eliminate existing connections in old installations. The older type of pressure filter system provides poor facilities for chemical addition, mixing, and contact. Positive feed or open type chemical machines are far preferable to alum and soda ash pots and their use is recommended. Where possible,mixing and coagulation basins would be desirable. In some pools, soda ash addition direct to the pool by hand has been preferred to soda ash pots.

F. Misuse of alum coagulants is very common. Too much alum coagulant may be used and experience has indicated that good results are often obtained with small amounts of alum or no alum. Ammonia alum will frequently result in formation of chloramines from ammonia and chlorine in the pool water with less effective disinfection; other compounds of aluminum such as aluminum sulfate are preferably used.

G. Readily removable heads or a large manhole should be provided on pressure filters to

facilitate inspection and repairs. Sufficient head room and working space must be allowed about filter units of all types to permit sand replacement and other repairs when necessary.

H. When the water supply for a pool contains large quantities of calcium bicarbonates, and especially when such water must be heated for use, difficulty is often experienced in maintaining clear water in the pool by the usual methods of coagulation and filtration. To a certain extent, this difficulty may be overcome by passing the alum-treated water through a properly designed coagulation and sedimentation basin before filtration. Where the installation of a proper coagulation basin is impracticable, it is suggested that water softening apparatus of the zeolite or base exchange type be installed as an adjunct to the recirculation system to permit the calcium content of the pool water to be reduced to a reasonable amount.

I. In an effort to evaluate operating results from diatomaceous earth filters, the committee recently (1955) questioned the state sanitary engineers relative to their experience. The reports from the chief sanitary engineers of 48 states and one territory indicate that 26 had observed generally satisfactory operating results with diatomaceous earth filters, 13 reported unsatisfactory operating results, two reported fair operating results, and eight reported either no experience with these filters or stated that no definite information was available. Several state sanitary engineers gave their opinion that better qualified operators and better character of operation were needed to get good operating results from diatomaceous earth filters as compared with pressure sand filters which often did well under inferior operating supervision. Lack of good operating supervision has created problems.

Summarizing on the basis of reports from the state sanitary engineers and of published experience elsewhere, the committee has the following comments on diatomaceous earth filter operation:

1. Properly designed diatomaceous earth filters have given good service where good operation has been provided.

2. The type of operator and the character of supervision must be higher for successful operation than with the more conventional pressure sand filter.

3. Filtration rates of 2 gallons per square foot per minute seem to be on the safe side; rates should not exceed 3 gallons per square foot per minute and at this rate heavy bathing loads or other factors may reduce filter runs to the point of giving trouble unless compensated by good operation.

4. Diatomaceous earth filters will not materially reduce color and are of questionable value for treating colored waters; also, waters high in content of iron and manganese may give trouble in diatomaceous earth filtration systems.

5. A filter aid type system should be operated by intelligent, responsible and properly trained personnel. Instructions for backwashing and recharging must be carefully followed and backwashing should take place before the rate-of-flow meter shows too much drop below the design rate. Rate-of-flow meters are needed.

6. Corrosion of filter elements and filter shells, poor design and manufacture of elements, poor installation and insufficient cleaning during backwash, as found by Cary and Levin, according to a published account of investigations in Washington, D. C., are items that merit attention from manufacturers and operators.

18. Disinfection

A. The addition of chlorine by means of suitable apparatus is today the most widely used method of pool disinfection and is satisfactory. It makes possible not only the disinfection of the entire body of water in the pool, but also the maintenance in the pool water at all times of chlorine residual that will counteract dangerous contamination introduced by bathers. The gas hazard is eliminated by the use of stable chlorine solutions but it should be ascertained that hypochlorinators are of sufficent capacity for adding adequate amounts of chlorine and that solution tanks be sufficiently large as not to require too frequent replenishment. By use of the proper chlorinating apparatus, it is also possible to vary the dosage to compensate for changes in the bathing load. Chlorine may be applied as a solution of chlorine gas in water or as a hypochlorite solution. There should be disinfection of all indoor pools and of all outdoor pools where there is any appreciable bathing load. The combination of ammonia with chlorine for swimming pool

disinfection has come into some use because of the greater persistence of the chloramines formed and the possibility of carrying higher disinfecting dosages without irritation of the mucous membranes.* Chloramines, however, are decidedly weaker or slower acting disinfectants than is the HOCl released when chlorine is added to water. It appears to the committee, therefore, that the use of chlorine is more satisfactory than that of chlorine and ammonia, although in some installations, such as very large pools or outdoor pools, chloramine disinfection may produce better overall results. Reports have reached the committee of avoidance of loss of titratable chlorine from disinfected swimming pool water and of less trouble with chlorine odors by carrying high alkalinities in the water. This is due to the smaller relative concentration of HOCl and the higher relative concentration OCl^- ion in water of high pH value. The disinfecting value of OCl^- ion, however, is much less than that of HOCl, and pH values above 7.5 should, therefore, be avoided if rapid and effective disinfection are to be insured.

Attention is called to experience in some pools where chlorine and ammonia have been used and where there has developed the presence of excessive amounts of nitrites. These have caused false readings with the orthotolidine test for residual chlorine. The committee recommends that where chlorine and ammonia are used, frequent nitrite determinations be made on the swimming pool water in addition to the routine check of bacteriologic examinations. Even in pools where chloramine disinfection is not employed, it may prove advisable to make some tests for nitrites. They have been found to a noticeable extent occasionally in such pools.

Most experience appears to indicate that better results are obtained by adding chlorine ahead of pool filters. In designing new pools, provisions may well be made for application either before or after filters.

B. The hazard of accidental escape of chlorine gas into public buildings is such as to warrant special precautions. It is suggested that:

1. The chlorine and chlorine equipment should be placed in a separate room which is reasonably gas tight and equipped with air eduction ducts beginning near the floor level and terminating out of doors. It is preferable to equip such rooms with forced mechanical ventilation capable of changing the air therein at least twice each minute. If the location be below ground level, such mechanical ventilation should be considered a minimum requirement, since chlorine gas is heavier than air and will not rise from sub-ground levels.

2. The chlorine equipment placed therein should be of rugged design capable of withstanding reasonable wear and tear without developing leaks. Cylinders of liquid chlorine should be suitably anchored to prevent their falling over.

3. Some form of protection should be provided for emergencies. Several types of gas masks approved by the U.S. Bureau of Mines and suitable for high concentrations of chlorine are available. For this purpose, a sufficient number of suitable gas masks should be at hand and located at a readily accessible point outside of the area likely to be affected in case of accident. The instructions accompanying a mask concerning its care and use should be obeyed implicitly . Everyone who is in danger of being accidentally exposed to high concentrations of chlorine should be provided with a gas mask. Periodic strict inspection and maintenance of approved gas masks are essential.

C. There are now on the market machines which feed hypochlorite solutions for disinfection. Chlorine compounds may be used to make up fairly stable disinfecting solutions and so long as their strength is checked by means of residual chlorine tests on the pool water, they may be very satisfactory. There are also chlorinators in use which produce chlorine by electrolytic action on sodium chloride solutions.

D. Intermittent disinfection with hypochlorites as practised at many pools must be considered a makeshift. It is possible to obtain satisfactory disinfection by intermittent application of these chemicals and to maintain a satisfactory residual chlorine content in the water when the bathing load is constant and not too high. When the bathing load fluctuates widely, the residual chlorine content cannot be adjusted to compensate for these variations and under excess loads immediate disinfection of infectious matters from bathers may not be accomplished.

*More recent work indicates that high-free residual chlorination for disinfection of swimming pool water, although presenting a number of new problems needing study, nevertheless reduces the amount of irritation to the eyes of swimmers as compared with the usual marginal chlorination when the pH of the water is 8.0 to 8.9 and the residual chlorine level is 1.0 to 3.99 p.p.m. with the principal portion of the fraction as free residual chlorine.

E. Bromine has been used for swimming pool disinfection in recent years in a large number of pools, particularly in the Middle West. Reports by the Illinois State Department of Health indicate favorable results and the committee knows of no reason why it cannot be used successfully. The equipment for adding the chemical may be improved in some respects as experience develops but has in general operated satisfactorily in Illinois. Caution in handling bromine is advised because upon contact with the skin, it causes burns. Also, it vaporizes rapidly at room temperatures giving off irritating fumes. On the other hand, it is a liquid under normal conditions and there is no hazard of the type associated with compressed gas. The test for bromine residuals is somewhat similar to the test for chlorine residuals. Orthotolidine is used as an indicator with matching of color standards. Additional independent studies of pools disinfected with bromine should be made and the results published. Mallmann, Vandervelde, and Moore in a paper presented before the American Public Health Association in 1946, reported on "A Comparative Study of Chlorine and Bromine for Swimming Pool Disinfection." Some of their conclusions are of interest:

1. Nearly the same bacteriological results were obtained when a residual of 0.5 p.p.m. of either bromine or chlorine was used.
2. It was found from routine operation that it takes about twice as much bromine by weight to carry a residual of 0.5 p.p.m. as it takes with free chlorine.
3. Coli indices are usually zero at normal residuals of bromine or chlorine.
4. Satisfactory equipment can be developed for applying bromine to swimming pools.
5. Irritation of the eye does not result with bromine or chlorine when used at normal concentrations.

F. Sterilization of clear water may be obtained by exposure in thin films of ultra-violet rays. It is claimed by the proponents of this method of swimming pool disinfection that the water after treatment contains a residual disinfecting agent whose action is similar in effect to that which is obtained by the use of a slight excess of chlorine either as gas or in solution. So far as the committee has been able to determine, no conclusive evidence has been produced to establish the claim. Until such evidence is produced, it must be assumed that disinfection by this process proceeds according to the law of purification by consecutive dilution and is subject to the limitations imposed by that law. On this assumption there is never any definite and determinable amount of disinfectant in the pool water to act on infectious material which may be discharged by bathers during the bathing period at the time when such material is most dangerous. In a few cases, satisfactory control of the bacterial content of pool water has been reported by the use of ultra-violet disinfection alone. In a considerable number of instances, however, it has been found advisable to reinforce or supplement the ultra-violet treatment by treatment of the pool with chlorine or hypochlorites. Until reliable evidence is produced that ultra-violet treatment will cause the pool water to contain a sufficient residual disinfectant to take care of casual contamination and until methods have been devised by which any such residual disinfecting action can be readily determined and controlled, the committee cannot recommend the use of violet-ray apparatus alone for disinfection of any pool where the bathing load is high or where large temporary loads are likely to occur.

G. Judging from a few reports, a reasonably satisfactory disinfection of water may be accomplished by ozone when the necessary apparatus is properly installed and operated. The data on the use of ozone for swimming pool disinfection are very few and inconclusive. There is no evidence that ozone has any residual sterilizing effect after the water has been treated, and disinfection must, therefore, proceed according to the law of consecutive dilution and be subject to all limitations imposed by that law. On the basis of any available evidence, the committee cannot recommend this method of swimming pool disinfection.

H. The committee recommends the use of copper sulfate in combination with either of the approved methods of disinfection at such times and in such amounts as may be necessary to control growths of algae in swimming pools and other bathing waters. The use of copper salts alone as a disinfectant will not produce satisfactory bacterial control and cannot be recommended. One state reports that with the use of hard waters, chlorine is employed for algae control in preference to copper sulfate.

I. The use of ionized silver for swimming pool disinfection has been developed abroad and to a very limited extent in this country. While satisfactory bacteriological conditions have been reported in pools using such treatment, there is a question as to how rapidly this disinfec-

tant acts on infectious material which may be discharged into the pool water by bathers. Hale and Shapiro report poor disinfection with ionized silver treatment in New York City in experimental tests and during five months' practical tests in a swimming pool, and call attention to the relatively high cost of such treatment and to interfering substances such as ammonium salts. Mallmann also reports on operating results in a pool where ionized silver treatment was tried. He concluded that silver appears to be slower in its germicidal action than chloride when applied as a disinfectant for swimming pools, and bathing loads must be lower for silver treated swimming pools than when chlorine is used. He found three non-pathogenic bacteria that grew abundantly in swimming pool water containing silver. In the light of available information the committee cannot recommend the use of ionized silver for swimming pool disinfection.

19. Diving Towers, Spring Boards and Floats

A. Diving towers, when provided, shall be rigidly constructed and properly anchored at the bottom with sufficient bracing to insure stability under the heaviest possible load.

B. Some opposition has been registered to the use of fixed platforms and floats in the water because of the safety hazard. Where used, they shall be constructed with an air space of at least 1 foot beneath. There must be as little underwater construction in such platforms as is consistent with strength, and all braces, struts, etc., shall be designed to prevent entanglement or trapping of bathers beneath the platform. Spring boards, diving platforms and floats should be covered with non-slip material.

C. At least 13 feet free and unobstructed head room must be provided above diving boards and towers.

D. No diving board or platform more than 10 feet above water level should be permitted at any public place. The elevation of diving boards or towers should not exceed the safe limit for the average swimmer. In the fifth report of this committee certain minimum safe depths of water were suggested, corresponding to various elevations of diving platforms. Greater depths are now usually preferred and in order to be on the safe side, the committee recommends that a minimum safe water depth of 8 feet be provided for diving and in the case of diving platform elevated 9 to 10 feet above the water, it is recommended that this depth be increased to a minimum of 10 feet. In fact, some reports have reached the committee that many officials supervising swimming meets and pools extensively used for diving consider that in order to prevent touching of the pool bottom by divers, the minimum water depth below any diving board should be 10 feet. Attention of the committee has been called to possible hazards to divers using offset diving areas and cut-back dives where, despite sufficient depths under the immediate ends of the diving boards, there was insufficient depth to protect the divers in the areas of diving.

20. Safety Precautions at Swimming Pools

A. In general, construction, appliances and operation shall be such as to reduce to a practical minimum in swimming pools the danger of drowning and of injuries to bathers from falls or collisions. Various detailed suggestions to this end appear in this report.

B. Every swimming pool having a minimum horizontal dimension of less than 75 feet should be equipped for safety and rescue with: 1) One or more light but strong poles (bamboo or other) with blunted ends not less than 12 feet in length, for making reaching assists or rescues; 2) One or more throwing ring buoys not more than 15 inches in diameter having 60 feet of 3/16 inch manila line attached, placed on racks at strategic points adjacent to the pool.

C. Every swimming pool having a horizontal dimension of more than 100 feet should, in addition to the foregoing, be equipped with one or more fully equipped light and handy (10-12 foot length) lifeboats, for patrol and rescue purposes.

D. Every swimming pool should be equipped with a standard 24 units first aid kit which should be kept filled and readily accessible for emergency use.

E. Every swimming pool should have a readily accessible room or area designated and equipped for emergency care of casualties. Minimum equipment for the emergency room should be the first aid kit previously suggested, and a stretcher and two woolen blankets, for emergency only.

F. Every swimming pool should provide, immediately adjacent to its telephone, a selected list of telephone numbers for (1) nearest available doctors, (2) nearest available ambulance service, (3) nearest available hospital or hospitals, and (4) nearest available police or

fire department rescue squads.

21. Suits, Towels and Caps

A. At indoor pools used exclusively by men, nude bathing should be required. At indoor pools used exclusively by women, bathing suits should be of the simplest type. Suits when used should be of wool or cotton of simple design and of undyed material or tested for fastness of color. Elaborate suits of varied materials or varied colors should not be permitted.

B. At artificial pools all bathers with long hair should be required to wear rubber bathing caps.

C. It is desirable at artificial pools that all suits and towels be supplied and cared for by the management.

D. All such suits and towels should be washed with soap and boiling water, rinsed and thoroughly dried each time they are used. Some suits are made of materials that may be damaged by boiling water; disinfectants for this type of suit should not be relied on unless under adequate control. Where suit disinfection treatment is not employed, the pool management at least should adopt a routine whereby each suit brought to the pool is inspected so that any suit, which obviously is not in satisfactory condition, can be prevented from being worn in the pool area.

E. Unless suits and towels be sent to a public laundry, the installation and use of modern laundry equipment at all public bathhouses and pools should be required. Cold water washing and air drying should be prohibited. The use of a disinfectant on suits and towels in place of proper laundry methods is a makeshift which should not be permitted.

F. A sufficient number of suits and towels should be provided to take care of the maximum number of bathers. Unless thoroughly dried by artificial heat in a modern laundry drier, suits and towels should not be re-issued on the same day that they have been used.

G. Clean suits and towels must be kept strictly separated from those which have been used and unlaundered. Clean suits and towels must not be stored on shelves, handled in baskets, or passed out over counters where dirty suits have been.

22. Supervision of Bathers

A. A swimming instructor or other qualified attendant should be on duty at the poolside at all times when a pool is open to use by bathers. Such attendant should be in full charge of bathing and have authority to enforce all rules of safety and sanitation. At least one trained first aider should be among pool personnel.

B. An attendant should be on duty at the shower room or entrance to the pool to inspect all bathers for skin diseases, open lesions, etc., and to insure that a proper cleansing bath has been taken.

C. Swimming pool lifeguards and supervisors should be properly trained and qualified lifesavers, competent in aid and rescue methods and technics, and in the use of artificial respiration and other resuscitative measures.

Enough members of the pool staff should be trained and certified in first aid to insure that at least one person competent to care for injuries is on duty at all times when the swimming pool is in use.

D. No bather should be permitted to enter the pool room or pool enclosure unless an attendant or other competent person is present. Solo bathing must be absolutely prohibited at all pools.

E. Whenever a pool is empty, entrance of all persons except pool attendants must be effectually prevented.

23. Personal Regulations

A. All persons using a swimming pool must be required to take a cleansing shower bath in the nude, using warm water and soap, and thoroughly rinsing off all soap suds, before entering the pool room or enclosure. A bath after donning a bathing suit should not be permitted.

B. A bather leaving the pool room or enclosure for any reason should take a foot bath before returning. A bather leaving pool to use toilet should be required to take a second cleansing bath before returning.

C. All bathers should be instructed to use the toilet and particularly to empty the bladder before taking cleansing bath and entering the pool.

D. Any person having any skin disease, sore or inflamed eyes, cold, nasal, or ear discharges, or any communicable disease must be excluded from a public swimming pool.

E. Persons having any considerable area of exposed sub-epidermal tissue, open blisters, cuts, etc., should be warned that these are likely to become infected and advised not to use the pool.

F. Spitting, spouting of water, blowing the nose, etc., in the pool should be strictly prohibited. Bathers should be instructed that the scum gutter is provided for expectoration.

G. All bathers should be instructed that blowing the nose to remove water is likely to force infectious matter into the sinus and inner ear cavities and possibly cause serious consequences.

H. Divers should be advised to wear rubber caps over the ears, and the use of nose clips is a protection for divers.

I. No boisterous or rough play, except supervised water sports should be permitted in the pool, on the runways, diving boards, floats, platforms or in dressing rooms, shower rooms, etc.

J. Suitable placards embodying the above personal regulations and instructions and those relating to suits and towels should be conspicuously posted in the pool room or enclosure and in the dressing rooms and offices at all swimming pools. At a number of boys' club pools, the boys are required to memorize the rules for safety and sanitation as a prerequisite to use of the pool.

24. Chemical and Physical Quality of Swimming Pool Water.

A. Excess Chlorine -- Whenever chlorine, calcium hypochlorite, or other chlorine compounds, without the use of ammonia, are used for swimming pool disinfection, the amount of available or excess chlorine in the water at all times when the pool is in use shall not be less than 0.4 p.p.m. or more than 1.0 p.p.m. except where high-free residual chlorine is used as described below. Available data indicate that for the most effective results this should be present as free available residual chlorine. Whenever chlorine or chlorine compounds are used with ammonia, effective results have been reported where the amount of available or excess chloramine is between 0.7 and 1.0 p.p.m., but recent reports suggest the desirability of operating with higher chloramine residuals such as 2.0 p.p.m. and there is a trend away from chlorine and ammonia disinfection in properly designed pools, inasmuch as less reliable disinfection is accomplished. Attention is directed to the possibility of interference by nitrites with the orthotolidine test, particularly when chlorine-ammonia disinfection is employed. If readings be made on the water to be tested within 5 to 10 minutes after the orthotolidine is added, and samples are kept away from the light during this period, the nitrite interference will be decidedly lessened. Standards for determining chlorine residuals shall be prepared and used according to the recommendations in Standard Methods for the Examination of Water and Sewage of the American Public Health Association. Standardized color discs and comparators may be used.

B. High-Free Residual Chlorine -- A new development in the United States, "High-Free Residual Chlorine," has been based on successful English practice whereby advantages have been cited in maintenance of relatively high concentrations of free available chlorine (1.0 p.p.m. or above) with accompanying high alkalinity (usually pH 8.0 to 8.9), as compared with lower chlorine residuals and pH of 7.0 to 7.5 as generally practiced in the United States. Advantages claimed are: more consistent satisfactory bacteriologic conditions, especially in outdoor pools, clearer pool water, and less irritation of the eyes of swimmers. A disadvantage is the higher cost of chlorine. This development is looked upon with considerable favor by some who have observed it in the United States and its progress will merit watching.

C. Acidity-Alkalinity -- Whenever alum or sulfate of alumina is used during purification or repurification of swimming pool waters, the water at all times when pool is in use shall show an alkaline reaction. This means that the hydrogen ion content of the pool water shall not fall below 7.0.

D. Clearness -- At all times when the pool is in use, the water shall be sufficiently clear to permit a black disc 6 inches in diameter on a white field, when placed on the bottom of the

pool at the deepest point, to be clearly visible from the side walks of the pool at all distances up to 10 yards measured from a line drawn across the pool through said disc. This is a minimum standard and most pools with modern filtration systems produce water far clearer than this minimum safety standard. Accident prevention is an important reason for maintaining clear water, and very clear water adds greatly to the pool attractiveness.

E. Temperatures -- The water in any swimming pool should be artificially heated to a temperature above 78°F. The temperature of the air at any artificially heated swimming pool must not be permitted to become more than 8°F. warmer nor more than 2°F. colder than the water in the pool at any time when the pool is in use. For best results it is desirable that air temperatures shall be about 5°F. warmer than the pool temperature.

25. Bacterial Quality of Swimming Pool Waters

A. Bacteria Count on Standard Nutrient Agar --24 hours -- 37°C. -- and Confirmed Test -- Not more than 15 percent of the samples covering any considerable period of time shall contain more than 200 bacteria per ml. or shall show positive test (confirmed test) in any of five 10 ml. portions of water at times when the pool is in use. All primary fermentation tubes showing gas should be confirmed.

B. All chemical and bacterial analyses should be made in accordance with the procedures recommended in the Standard Methods for the Examination of Water and Sewage of the American Public Health Association in so far as these methods are applicable to swimming pool waters. In order to secure a true picture of the condition of the swimming pool water at the time of sampling, it is recommended that sodium thiosulfate be employed to neutralize the chlorine residual in the water sample bottle during transportation to the laboratory.

C. The part played by the various strains of streptococci in the respiratory diseases and their prevalence in the intestinal, buccal, and nasal discharges make the presence of streptococci in bathing waters very undesirable. Yet to eliminate them from swimming pools would mean decidedly smaller bathing loads and decided increases in chlorine residuals, either or both of which would hamper the usefulness of the pool. The committee calls attention to the fact that streptococci tests are of value in passing on the conditions of swimming pool water but does not recommend any uniform standard limit for their presence.

D. 1. Preparation of bottle for sampling --

All samples of chlorinated swimming pool water shall be collected in bottles treated with sodium thiosulfate. The purpose of using water sample bottles containing sodium thiosulfate is to reduce the chlorine present in a treated water at the moment the sample is collected to prevent a continuance of the killing action of the chlorine on the bacteria while the sample is being transported to the laboratory. The bacteriological examination then shows the true sanitary quality of the water at the time the sample was collected.

2. Several procedures for preparing the bottles are presented.

For moist heat sterilization --

Option 1 -- The sodium thiosulfate solution is prepared by dissolving 1.5 gm. of sodium thiosulfate in 100 ml. of distilled water. One-half ml. of this solution is placed in each clean bottle. (This amount has been found sufficient to reduce completely residual chlorine in an amount up to 2.0 p.p.m. in a sample of 130 ml. of water.) After the introduction of the sodium thiosulfate solution, the bottle is stoppered and capped. The bottles are then placed in an autoclave and sterilized for 15 minutes at a pressure of 20 pounds per square inch.

Option 2 -- Into clean wet bottles, add approximately 0.02 to 0.05 gm. of powdered sodium thiosulfate. The amount need not be weighed. An estimated amount on the tip of a spatula is sufficiently accurate. The bottles are sterilized as in Option 1.

For dry heat sterilization --

Into clean dry bottles is added from 0.02 to 0.05 gm. of powdered sodium thiosulfate as in Option 2. The bottles are stoppered, capped, and sterilized at 180°C. for 10 minutes. The temperature of sterilization must not approach 220°C. as sodium thiosulfate decomposes at this temperature.

E. Collection of Samples -- The samples should be collected by plunging the open bottle beneath the surface, sweeping the bottle forward until filled. The bottle should not be rinsed in the pool or the sodium thiosulfate will be removed. Samples should be collected only when the pool is in use and preferably during periods of heaviest bathing loads during the day. The hour of the day, the day of the week, frequency of collection, and the location of the point of sampling shall be varied in order to obtain over a period of time a representative cross-section of the sanitary

quality of the pool. It is desirable wherever facilities permit, to collect one or more samples weekly from swimming pools.

26. Cleaning Pool

A. Visible dirt on the bottom of a swimming pool shall not be permitted to remain more than 24 hours.

B. Any visible scum or floating matter on the surface of pool shall be removed within 24 hours by flushing or other effective means.

27. Bathing Load Limits

A. Frequency of Changing Water—

1. The purpose of recirculation is primarily twofold, first to remove suspended material and thus produce a clear water, and second, to carry chlorine or chloramine to the water in the pool and thus maintain proper chlorine residuals in the pool water. The clarity of the water is related to the efficiency of the chlorine, in that the presence of suspended material reduces the effectiveness of the residual chlorine. In general, as discussed in Section 16-B, it has been found that the rate of turn-over should be three times daily where continuous circulation is used.

2. The total number of bathers using a fill and draw swimming pool shall not exceed one person for each 500 gallons of water in the pool between complete changes of pool water without disinfection. Where intermittent disinfection is employed, the number of bathers using the pool will be governed by the safe limits mentioned under "Proportioning Pool Area to Expected Load," and by bacteriological analyses of the pool water. Chlorine residuals should be maintained within the limits discussed in Section 24-A. The committee does not recommend the use of fill and draw swimming pools, as stated elsewhere.

3. The total number of bathers using an outdoor pool — partly artificial and partly natural in character, dependent for circulation and replenishment upon an inflow and outflow of water from the supply of a clean stream which is relatively free from bacterial pollution or of a safe well or spring — might be based upon a figure of one person for each 500 gallons of water added to the pool as a maximum limit, although safe bacteriological conditions should be the principal guide. Where pre-cleansing baths are not used at such pools, reductions in bathing loads will undoubtedly be found necessary to maintain safe bacteriological conditions even with high chlorine residuals. Pre-cleansing baths should, of course, be provided at all pools.

B. Frequency of Disinfection — The committee has decided to omit a previous recommendation as to bathing load limits between sucessive disinfections in pools practising intermittent chlorine disinfection in view of the recommendations as to maintenance of adequate chlorine residual at all times the pool is in use. It is pointed out that experience indicates that far better bacteriological conditions can be maintained with continuous chlorine disinfection. Where a pool is operated with wide fluctuation in chlorine residuals, chlorine resistant organisms may develop at times when the chlorine residual content of the water is low, and it may be necessary to use very high chlorine residuals to destroy them.

C. Area Limitation— One investigator (Mallmann) has concluded that under normal pool recirculation and design conditions, a maximum bathing load limit of one bather per 35 to 45 square feet of pool area will result in safe bacteriological conditions with adequate chlorine residuals. In the light of experience, these figures seem reasonable for swimming pools which are of ordinary dimensions. The area per bather is greater than provided for under the design requirements set under "Proportioning Pool Area to Expected Load," section 6.

D. Becker has suggested a formula for determining satisfactory bathing loads, which the committee submits as a matter of information without recommendations. Formulae are difficult to apply on account of the many variables.

$$BL = \frac{3.84 \times C,}{T^3} \quad \text{where}$$

BL = Bathing load (daily maximum)
C = Capacity of the pool in gallons.
T = Turnover of pool circulation system in hours.

Hyatt has suggested modification of the factor 3.84 by submitting substitute figures ranging from 2.0 to 6.4 for varying types of pools, on the basis of distinction between outdoor and indoor pools, sexes of bathers, and conditions of operation.

28. Operating Control

A. Trained Operators —Each swimming pool should be operated under the close supervision of a well trained operator with common sense and good judgment.

B. Tests for Excess Chlorine —At any pool where chlorine, hypochlorite of lime or other chlorine compound is used for disinfection, the operator must be supplied with a proper outfit for making the orthotolidine test for excess chlorine and with permanent standards showing maximum and minimum permissible chlorine in the water.

Tests for excess chlorine in the water shall be made as frequently during the day as experience proves to be necessary to maintain adequate residuals.

C. Tests for Acidity —At any pool where alum or sulfate of alumina is used or where artificial alkalinity is added to the water, the pool operator must be equipped with a hydrogen ion testing outfit and must take hydrogen ion tests on the water every day the pool is in use, and more often if necessary.

D. Operating Records —Every pool operator must be supplied with a proper notebook or with blank forms on which shall be recorded every day the number of persons using the pool, peak bathing loads handled, the volume of new water added, the temperature of the water, and the temperature of the air. Whenever a pool is used by both males and females the number of each and whether adults or children should also be recorded. At all pools where artificial circulation, filtration, or any chemical treatment is used, a full daily record must also be kept of the actual time pumps and filters are in operation, of the time each filter is washed or cleaned, of the time and amount of each chemical used or added, of the time the bottom and sides of the pool are cleaned, and the results of all hydrogen ion, excess chlorine, or other tests.

Outdoor Bathing Places

29. Definition

Under this heading are considered bathing places along small streams, rivers, lakes, and tidal waters. Fill and draw and recirculation swimming pools readily subject to artificial purification or to constant replenishment with uncontaminated water are not included.

30. Sources of Pollution

In a swimming pool whose water is derived from a public or other supply of unquestioned quality, it may be assumed that the presence of organisms of the coli-aerogenes group indicates pollution by human sewage particles. The presence of such bacteria in outdoor bathing places, however, may be due to the wash from cultivated fields, animals, and generally harmless contamination. Routine bacteriological tests do not differentiate between harmful and harmless contemination in such cases. Harmful contamination may be caused by sewage from boats, individual dwellings, hotels, factories, or other establishments, public sewerage systems, refuse dumping, and bathers themselves.

31. Flowing-Through Bathing Pools Along Small Streams

The use of small natural or dammed-up pools along small streams by large numbers of bathers is not recommended unless disinfection is provided, as discussed in the following section. Where such pools are proposed to be used, and will be dependent upon the natural stream flow for cleansing and dilution, it should be ascertained that there is a constant and appreciable overflow of water past the dam under all weather conditions when the pool is to be used. Any small pool patronized by a number of bathers is certain to show bacteriological pollution in considerable amounts unless disinfection is provided. While no specific amount of diluting water for such pools can be recommended, it is probably fair to say that less than 500 gallons per bather per day is too small a diluting volume without disinfection.

In New York State, the so-called Becker formula has been used as a practical guide in passing on necessary volumes of diluting water. This formula is $Q = 6.25\ T^2$ where Q = quantity of water per bather and T = the replacement period in hours. For example, if the flow is such as to replace the pool volume in 8 hours, Q = 400 and the number of bathers permitted in 8 hours would be the capacity of the pool divided by 400. When the replacement period is 12 hours, 900 gallons per bather are required by this formula.

Whether or not disinfection is employed, every effort should be made to eliminate all sources of sewage pollution of small streams or ponds used for bathing and careful sanitary surveys of watersheds are recommended. It is, of course, desirable that bathing be limited to relatively clear bodies of water and that muddy bottoms which will result in turbid water be avoided.

32. Disinfection of Small Flowing-Through Bathing Pools

Disinfection is desirable to counteract pollution introduced by bathers. Hypochlorite in solution may be added to the pool inlet or at various points over the pool area. Chlorination of the pool inlet may be continuous. Several applications of disinfectant over the pool area during the bathing period are usually preferable to one application. Even with disinfection, the same governing factors should be considered in arriving at maximum bathing loads in small outdoor pools as presented under "Swimming Pools" (sections 6 and 27,) and also the same limits for chlorine residuals are recommended as for swimming pools. Disinfection of large bodies of water is discussed in the following section.

33. Disinfection of Large Bodies of Water

The disinfection of relatively large bodies of water by use of a chloroboat, so-called, has been used with apparently some success in a few scattered instances. In some locations, bathing areas several acres in area have been disinfected satisfactorily by the use of extensive piping systems along the water bottom either for distribution of chlorine disinfecting solutions or for distribution of large amounts of pumped water drawn from the bathing area and disinfected in the pump suction with chlorine or chlorine and ammonia in what is practically a recirculation system. Where such disinfection is feasible, the same contents of chlorine and chloramine residuals are recommended as have been proposed for swimming pools. Chlorine and ammonia are undoubtedly more practical of application for large outdoor bathing areas than chlorine alone due to the greater persistance of the chloramines in the water. This probably outweighs the disadvantage of the slower disinfecting action of the chloramines as compared with chlorine. While the possibilities of disinfection methods deserve consideration, unless the future brings forth further developments in the way of attempt to establish bacteriological standards for outdoor bathing places, it appears that emphasis will be laid on the reduction of pollution of outdoor bathing areas rather than on attempt to counteract such pollution by disinfection of bathing waters. The use of disinfecting agents, however, may be developed particularly to guard against dangers from pollution by bathers themselves in those densely populated bathing areas which are not subject to major water changes through the action of tides and currents.

34. Collection of Samples from Outdoor Bathing Places

Analyses of samples of bathing waters intelligently interpreted are of great value but full consideration should be given to the conditions under which samples are collected and the conditions which may exist at other times. The replenishment of bathing water by stream flow, by tidal action, and by wind and temperature currents, the contamination introduced by bathers themselves and the intermittency of various sources of sewage pollution, are all of importance. In considering dangers from sewage pollution of bathing areas, it is well to emphasize that time is a factor of great importance. The hazard from a relatively small amount of sewage pollution in close proximity to a bathing area is far greater than a large amount at a considerable distance.

35. Bacteriological Examination of Waters of Outdoor Bathing Places

In the examination of samples of bathing waters in connection with a scheme of relative classification which is subsequently presented, it is suggested that the number of coliform organisms present be reported in terms of the most probable number as computed from the results of fermentation tests. For this purpose the following inoculations may be made from the sample. Three tubes may be inoculated with 10 ml. of undiluted water; three tubes inoculated with 1 ml. of undiluted water; and three tubes inoculated with 0.1 ml. of undiluted water (or 1.0 ml. of a 1 in 10 dilution of water). It may also be desirable where conditions warrant to carry dilutions down

to 0.01 ml. or even still further. Instead of three tubes, five tubes may be examined in each dilution if desired, but to attempt to secure such a degree of accuracy does not seem warranted ordinarily, especially where laboratory limitations may restrict the number of samples that can be examined should the greater number of tubes be examined in each dilution. One state uses only two tubes in each dilution in computing most probable numbers.

Most supervisory authorities now consider that confirmatory tests as with brilliant green bile following presumptive tests on lactose broth are the most satisfactory indication of the presence of coliform organisms, the resulting error as against complete confirmation according to Standard Methods for the Examination of Water and Sewage being slight. It is obvious that good judgment must be exercised in connection with any sampling program for outdoor bathing places. Large bodies of water are frequently being examined and the examination, as outlined, of large numbers of samples collected under a variety of conditions is preferable to more comprehensive laboratory processing of a small number of samples not representative of changing factors known to exist through a sanitary survey. In other words, deficiencies in sampling frequently may outweigh possible discrepancies in laboratory methods.

For the purpose of this report, the term "coliform index" is used to mean most probable numbers of coliform organisms.

36. Bacteriological Standards for Outdoor Bathing Places

In passing on waters of outdoor bathing places, three aids are available: (1) the results of chemical analyses of the water; (2) the results of bacteriological analyses of the water; and (3) information obtained by a sanitary survey of sources of pollution, consideration of flow currents, etc. Chemical analyses may in some cases be of value but are not ordinarily delicate enough tests.

It is not considered practicable nor desirable to recommend any absolute standard of safety for the waters of outdoor bathing places on any of the three above bases. The arbitrary wholesale condemnation of bathing beaches representing large capital investments is unwarranted without definite epidemiological evidence. A relative scheme of classification of outdoor bathing places appears to offer the most promising program for public health workers to follow. Due to the difference in local conditions surrounding bathing in tidal waters, large and small lakes, and large and small streams, the degrees of classification of the bathing waters in any particular region may of necessity be varied.

In appraising bacteriological condition of bathing waters, allowances must be made and distinction drawn as to contamination introduced by large bathing loads in outdoor bathing waters and pollution derived from sewer discharges or other sources. Stirring up of bottom sediment by bathers may result in greatly increasing the bacteria count in the water.

There is still a wide divergence of opinion as to standards of acceptable bacteriological quality for outdoor bathing places in streams, rivers, lakes and tidal waters, although there is apparently some crystallization of thought on the subject. Comparisons of standards suggested previously and those now proposed are somewhat confused by the general change from the use of the so-called Phelps* index based on computations from the examination of only one tube in each dilution to the use of the coliform index representing most probable numbers computed on the basis of examination of three or more tubes in each dilution, as recommended herein. Roughly, the Phelps index figures should be multiplied by 2.4 to obtain an equivalent coliform index. Inasmuch as "most probable numbers" are now recommended in Standard Methods for the Examination of Water and Sewage as an expression of density of coliform organisms, it is recommended that the use of the Phelps index be discontinued in defining density of coliform organisms.

Early attempts to set a limiting bacteriological standard equivalent to 120 coliform organisms per 100 ml. (50 coliform organisms per 100 ml. according to the Phelps index) have been largely discarded. Such figures are usually attainable only in lakes, and excellent quality tidal waters.

*For example, a sample showing + in 10 ml., + in 1.0 ml., and 0 in 0.1 ml., is considered to have a coliform content of 100 per 100 ml., according to the Phelps index.

Streams which are subject to no pollution other than animal contamination may often show a coliform index (as used herein) of 240 to 1,000 per 100 ml., with occasional samples showing still higher indices. In West Virginia, the State Water Commission describes a Class A water as a good source of recreational water where the average coliform index of samples each month does not exceed 1,000 per 100 ml.

In a resolution of the Great Lakes and Upper Mississippi River Boards, tentative interpretations of coliform densities are suggested as follows: "Waters showing a coliform index between 100 and 500 per 100 ml. are considered to be normal for inland streams free of detrimental sewage pollution; waters showing a coliform index above 500 but under 1,000 per 100 ml. are considered to be somewhat suspicious with general indication of mild pollution in natural waters although dangerous in proximity to fresh sewage pollution; waters showing a coliform index approaching 10,000 per 100 ml. are considered to show definite evidence of fresh sewage pollution and to be a menace to health in connection with bathing; and waters showing a coliform index approaching 100,000 per 100 ml. are considered to show heavy sewage pollution and to be definitely dangerous."

A report by a committee studying conditions for the T.V.A. reported that: "A coliform index of less than 50 per 100 ml. indicated a water of preferred sanitary quality but was not generally attainable; a coliform index of between 50 and 500 per 100 ml. indicated a state of contamination normal for inland streams free of detrimental sewage pollution but subject to surface wash, and unless there was convincing sanitary survey or epidemiological evidence to the contrary, bathing should be permitted in such waters; a coliform index of 500 to 1,000 per 100 ml. might be considered somewhat suspicious and would be considered dangerous if in proximity to fresh sewage pollution —comment is made that such densities may be due to harmless contamination; a coliform index of over 1,000 per 100 ml. was viewed with suspicion and was not recommended as acceptable for swimming unless a sanitary survey disclosed the reason for such high density and the cause was found harmless."

In one state, a classification survey of salt waters along the entire shore was carried out in 1945 and 1946. The shore line was divided into sampling stations about 1,000 feet apart and samples for bacteriological analysis were collected in from 2 to 6 feet of water at high, low, half ebb, and half flood tides at each station. The results were averaged and adjoining stations combined into sections on the basis of the sanitary survey information. The analytical classification for each section was made by averaging the averages for the included stations. The sections were then classified on the basis of the analyses as follows:

	Average Coliform Index per 100 ml.
Class A	0-50
Class B	51-500
Class C	501-1,000
Class D	over 1,000

These same sections were also classified in Classes A, B, C, and D on the basis of sanitary survey information as to sewer outlets, float studies, etc. In the sanitary survey classifications, Class A was considered good, Class D, poor; and the two intermediate classes ranged from fair to doubtful. Close correlation was reported between the analysis and sanitary survey classifications.

In the summer of 1948 the New York City Board of Health adopted a declaration of policy for the guidance of the Department of Health in classifying their bathing beaches. The action of the Board does not affect that section of the Sanitary Code which prohibits the operation of bathing establishments in certain specified areas. The classification adopted by the Board is as follows:

Class A: Approved Beach Waters

Group 1. Safe Waters

(a) Epidemiological experience satisfactory, and

(b) Sanitary survey satisfactory, and

(c) Coliform average not in excess of 1,000

Group 2. Approved, but subject to reclassification in light of continuing observation

(a) Epidemiological experience satisfactory

(b) Sanitary survey satisfactory but beach waters exposed to increasing pollution, or

(c) Coliform average about 1,000 but not in excess of 2,400

Class B: Polluted Beach Waters Not Recommended for Bathing

(a) Epidemiological experience satisfactory

(b) Sanitary survey discloses sewage material on beach or in water immediately adjacent to beach, and

(c) Coliform average above 2,400, with 50 percent of samples in average above 2,400

Class C: Unsafe Beach Waters

(a) Epidemiological experience discloses evidence of infection incident to beach bathing.

(b) and (c) Not necessarily relevent in light of (a) above

In connection with this system of classification, the Commissioner of Health will issue warning to the public and the proprietor of the beach that the waters of that bathing beach are polluted and not recommended for bathing when a beach falls in the Class B designation; when a beach falls in the Class C designation, warning to the public and the proprietor will be given by the Commissioner of Health and he shall, within 24 hours, call a special meeting of the Board of Health for the consideration of such other measures as appear necessary for the protection of the public health. This classification is reported to be based on epidemiological experience, bacteriological findings and sanitary surveys, and is influenced by the unique conditions found in the harbor waters of New York City.

As a commentary on the use of various standards for outdoor bathing places, the results of a series of three recent field studies of the Sanitary Engineering Center of the U.S. Public Health Service, which were undertaken in an attempt to determine the relationship between natural bathing water quality and health, are of interest. The studies were conducted on: (1) a Great Lake, namely Lake Michigan at Chicago, Ill.; (2) an inland river, namely, the Ohio River at Dayton, Ky., using a nearby swimming pool for comparative illness studies; and (3) a tidal water, namely Long Island Sound, at New Rochelle and Mamaroneck, N.Y. Studies were made not only of the bacterial quality of the waters used for bathing but also of extensive studies of illness records of persons bathing in the waters sampled. Results have been summarized by Stevenson and others.

In commenting on their studies, the report indicates: that a significant increase in illness in the Chicago studies was observed among swimmers who used one beach on three selected days when the water had an average content of 2,300 coliform organisms per 100 ml. and that in the Ohio River Study, despite the relatively low incidence of gastrointestinal disturbances, river swimming in water having a median density of 2,700 coliform organisms per 100 ml. appeared to have caused a significant increase in such illnesses among the swimmers. The following quotation taken from a summary abstract of the Public Health Service studies as applying to the establishment of very strict standards of bacterial quality for bathing places is worth repeating: "Admitting the difficulties of conducting studies in which nature rather than man controls many of the variables, sufficient evidence is available to indicate that some of the strictest bacterial quality requirements for natural bathing water now existent might be relaxed without significant detrimental effect on the health of the bathers. This always has been and will continue to be a matter of judgment."

The committee in commenting on this question of bacterial standards appreciates that the public expects health authorities to insist on some factors of safety and that bacterial quality standards which may seem somewhat strict may be recommended in cases where there is no intention of applying "Quarantine" until significant detrimental effect on the health of bathers is demonstrated or clearly threatened.

In considering limits to be set in standards, the question arises as to whether such limits should be applied to a single sample, or to an arithmetic average of coliform indices, or to a median of coliform indices, or to a geometric mean of coliform indices. The median is often considered fairest to use but this brings up the important fact that analytical data must be weighed and regarded along with the sanitary survey data. Samples collected at one point on various

stages of the tide might disclose truly dangerous conditions on one tidal stage due to the movement of sewage from outlets in the vicinity; in such a case, an arithmetic average might call attention to the danger more than a median; but the selection of either is less desirable in itself than an intelligent appraisal of the hazards from a knowledge of the analyses, the sources of pollution, tides, stream velocities, effect of wind, etc. One state has preferred to specify the percentage of samples within which there shall be no deviation from an established limit - in this particular case, 80 percent of the samples shall not show a coliform index in excess of 1,000 per 100 ml.

One worker (Thomas)* has pointed out that "a bacteriological code that merely specifies a limiting deviation (such as 20 percent) above a critical coliform index over-simplifies the issue to the extent that it obscures the distinction between tests with high indices that stem from real changes in the bacterial quality and that result only from random sampling fluctuations and therefore have no sanitary significance." He refers to the fact that the U. S. Public Health Service standard for drinking water is so devised that it takes cognizance of both types of deviations and accordingly is more rational than one limiting deviation. Thomas has also calculated allowances that should be made for sampling fluctuations; a tabulation he has prepared shows the marked dispersion of results from a fermentation tube test of this type in that about one-quarter of the tests indicated MPN values more than twice the true value and another one-quarter indicated MPN values less than one-half the true number. In connection with these comments by Thomas, it should be added that in the case of the limiting deviation used in the state referred to in the preceding paragraph this,is employed only with full consideration of the sanitary survey data, the importance of which is stressed elsewhere in this report.

The committee feels that the health board or department of each state should be the guiding agency for state-wide surveys of outdoor bathing areas with the assistance of community and district health units where practicable. Information obtained as a result of classification surveys of bathing waters should be in the hands of public health workers to enable them to furnish intelligent answers to inquiries on the part of the public. While data of this type should be released advisedly so as not to cause unwarranted depreciation of property values near bathing areas, they should serve to acquaint the public with danger spots caused by uncontrolled discharge of sewage and to promote healthful conditions by installation of sewage treatment where necessary for the protection of bathing waters.

It is emphasized that final classification of bathing waters should depend largely upon sanitary survey information. Bacteriological analysis findings should be used as a guide. Some areas of the country are reported to be able to meet bacterial standards for natural surface waters with maximum limits of coliform indices (as used herein) of not more than 240 to 500 per 100 ml. Such excellent quality is, of course, greatly to be desired. However, experience indicates that other sections of the country, especially those located in more densely populated areas and among cultivated lands, cannot maintain such conditions.

Waters showing a concentration of most probable numbers of coliform organisms of less than 1,000 per 100 ml. are considered in most such areas to be fairly acceptable for bathing unless the sanitary survey discloses immediate dangers from human sewage pollution; however, it must be admitted that bathing beaches where content of coliform organisms runs as high as 2,400 per 100 ml. on the basis of most probable numbers, or sometimes even higher, have been used without reported evidence of illness, and this limit of 2,400 per 100 ml. is still employed as a criterion of acceptability in some states. The trend is, of course, to reduce bacteria counts where possible by sewage treatment if human sewage be a threat, and the attainment of reasonable progress in this direction is to be hoped for. While bathing areas should always be free of visible forms of sewage matter that might contain pathogenic organisms, serious pollution may be present in many waters where treatment of sewage removes visible evidence of sewage solids but does not eliminate dangerous concentrations of bacteria.

Bathing in streams or ponds subject to gross animal pollution is not approved because of the possible danger of animal-borne virus diseases. At the same time, many inland waters have been found to show high figures for content of coliform organisms due to the effects of pastur-

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age and contamination from wild animals rather than human sewage pollution, and it has not been demonstrated that adverse health effects have resulted from bathing in such waters. This again calls attention to the need for considering both analytical findings and sanitary survey data.

37. Sanitary Appurtenances at Outdoor Bathing Places

A. Attention is directed to the need for proper sanitary appurtenances at outdoor bathing places. Most of the remarks in sections 12 and 13 under "Swimming Pools" with regard to dressing rooms, showers, toilets, and lavatory accommodations, are also pertinent as to outdoor bathing places.

B. In connection with shower facilities, one state health department suggests that for large bathing beaches, one warm shower should be provided for each 200 bathers allowed under maximum load conditions and at least one cold shower should be provided for each 10 warm showers or fewer. At public bathing beaches, a sufficient number of showers should be provided to permit all bathers to rinse off sand and dirt before entering the dressing rooms.

C. A foot trough with running water is desirable at entrances to out-door pools and to beach bathhouses. At certain pools operated in conjunction with surf bathing, it has been found advisable to make a wading pool of the entrance passage with automatic or continuous flow showers overhead through which all bathers must pass on return to the bathhouses.

38. Safety Precautions at Outdoor Bathing Places

A. At public bathing beaches, one or more life guards should be on duty during all bathing hours. They should be capable swimmers, competent in life saving methods and in methods of artificial resuscitation. Life guards should not be in the water except in the line of duty. Adequate supervisory service by life guards may be construed to mean a minimum of one life guard to every 100 yards of beach immediately adjacent to occupied bathing areas. It is recommended that life guards should be isolated from beach crowds by occupying elevated seats on stands or towers, just high enough to give them a complete and unobstructed view of the bathing and beach area for which they are responsible.

B. At every bathing beach there should be provided a sufficient number of life rings 15 inches in diameter with 75 feet of 3/16 inch manila line attached to each. Ring buoys when not in use shall be hung on racks equipped with 3 or 4 pins placed some 10 inches apart in a triangle or diamond formation on which rope can be coiled without kinking. It is recommended that one or more rescue devices known as swimming rescue buoys (diamond or torpedo type), equipped with 100-300 feet or longer if necessary of trail line (1/8 inch specially prepared stout cotton) be placed ready for use on each life guard stand.

C. At every bathing beach there should be provided at least one square-sterned boat equipped with oars, oar locks, and a life ring as described in the foregoing, ready for use. Lifeboats, as indicated, should patrol the outer fringe of standing bathers, one boat to every 200 yards of beach used for bathing purposes. Boats should not be permitted in the swimming area except when stationed there for emergencies. At all large bathing beaches, especially large beaches along the salt water, it is desirable that there be provided a surf boat not less than 16 feet long, on each side of which there shall be hanging ropes arranged so that persons in the water can easily catch hold of same and be supported thereby. Such boats should be equipped with two or more sets of oars and two sets of oar locks and at least two life buoys or life-preservers with 1/4 inch manila lines not less than 100 feet in length with suitable reels attached thereto.

Bathing beaches should be equipped with one or more paddle boards (hollow-type surf-boards) to be used as rescue devices. They should be kept in readiness at strategic points along the beach.

Every bathing beach, other than surf, may well be equipped with one or more sets of grappling irons held ready for use in a locker immediately adjacent to the bathing area, but not in view of the public. Where the water is clear, one or more waterscopes may be held in readiness for use with the grappling irons.

D. Safety regulations pertaining to swimming and boating should be conspicuously posted at each waterfront. At every bathing beach where safe limits are required, such limits shall be marked by buoys, poles or other markers located not over 100 feet apart and of a type visible to bathers from a distance of at least 100 feet and there shall be provided suitable signs on the beach describing such markers and stating that they indicate the limits of safe bathing.

E. In the case of salt water bathing beaches, one or more lines of sound, serviceable and strong manila or hemp rope, not less than 1 inch in diameter should be anchored at some point on the beach above high water and extended outward at right angles as far into the surf as bathing is ordinarily safe and free from danger of drowning to persons not expert in swimming. At such points of safety, such lines should be anchored and buoyed.

F. A first aid kit as recommended for swimming pools in section 20-C should be provided.

G. In some localities where bathing areas are in rough water, such as some surf locations, special precautions and equipment may be needed in addition to those outlined in this section.

39. Electrical Safety Code

There has been interest in the development of electrical safety requirements for all bathing places. The committee presents as an appendix to the report a suggested type of electrical safety code which is based largely on a code adopted by the Pennsylvania Department of Health.

APPENDIX

A. Proposed Electrical Safety Requirements for All Public Bathing Places

1. The entire electrical installation provided for public bathing places, their dressing and locker rooms, and other indoor and outdoor locations shall comply with and be maintained in accordance with requirements of the National Electrical Code.

2. All electrical wiring accessible to bathers (if run exposed) shall be in rigid conduit or electrical metallic tubing; and all boxes, fittings and accessories used in damp or wet locations shall be so installed and equipped as to prevent the entrance of water. (See Article 346, Section 3464, and Article 348, Section 3484--National Electrical Code.)

3. Distribution centers, where fused switches or circuit breakers are grouped, shall be enclosed and located so as to be inaccessible to other than authorized persons.

4. In addition to the grounding requirements for electrical equipment and circuits as required by the National Electrical Code, all water and other piping to and from the public bathing place, including inlet and outlet pipes, shall be metallically bonded together and adequately connected to the same grounding electrode used to ground the neutral conductor of the electrical system. (See Article 250, Section 2554--National Electrical Code.)

5. Pumps, filters, and other mechanical and electrical equipment shall be enclosed in such manner as to be accessible only to authorized persons and not to bathers. Construction and drainage shall be such as to avoid the entrance and accumulation of water in the vicinity of the electrical equipment.

6. All electrical devices such as portable announcing systems, radios, soft drink dispensers, etc., that might be used around the pool deck and immediate environment shall be prohibited in pool decks within reach of people on the decks. Further special grounding of such fixtures must be provided.

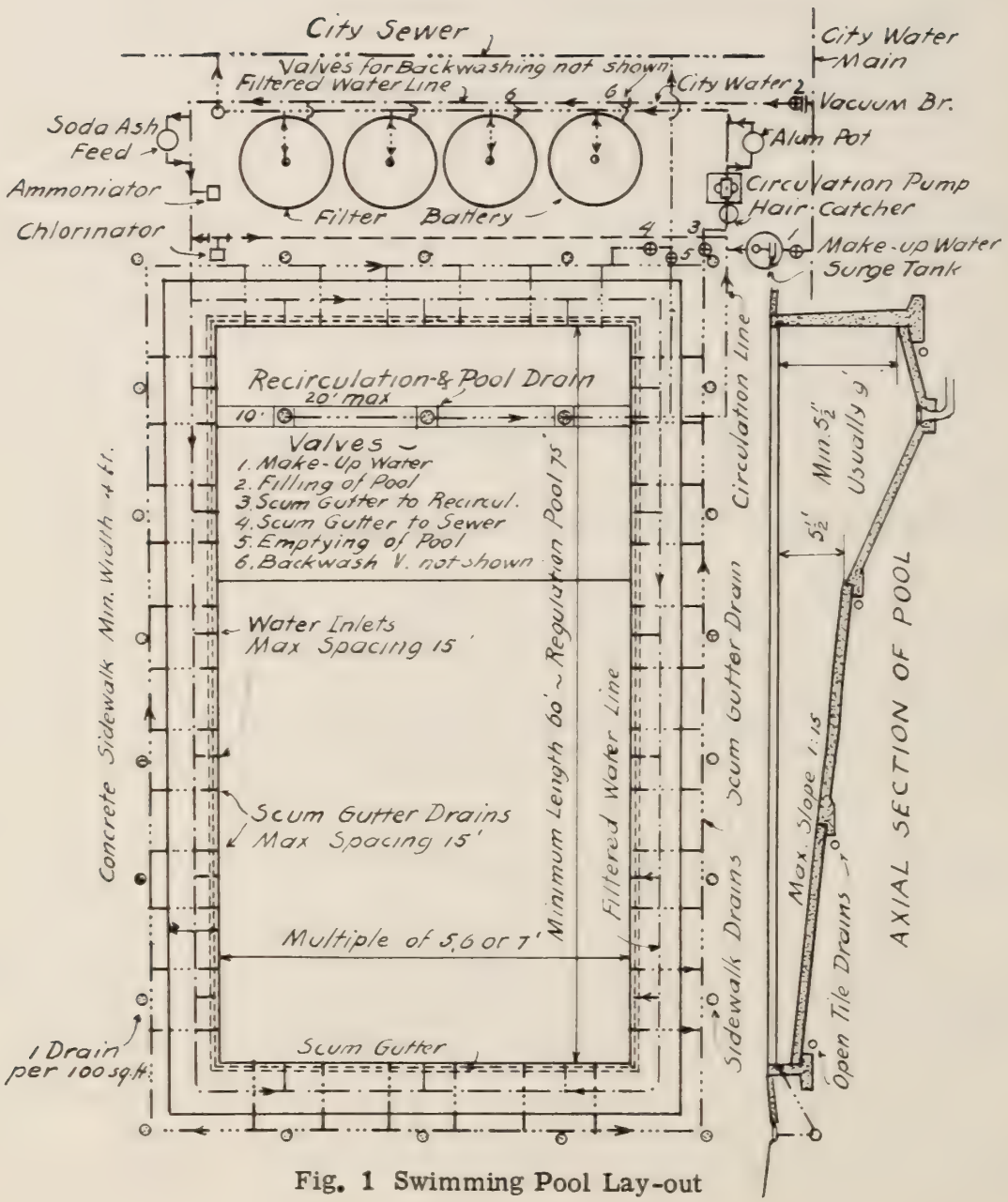


Fig. 1 Swimming Pool Lay-out

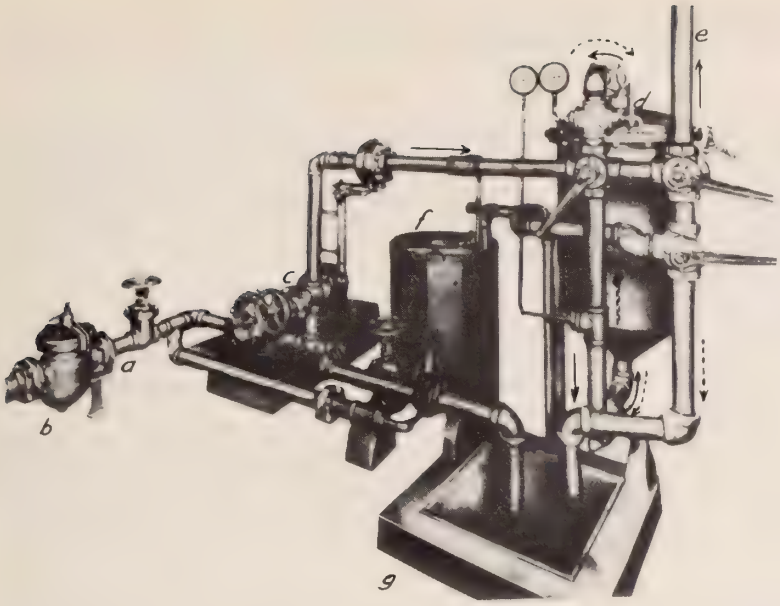
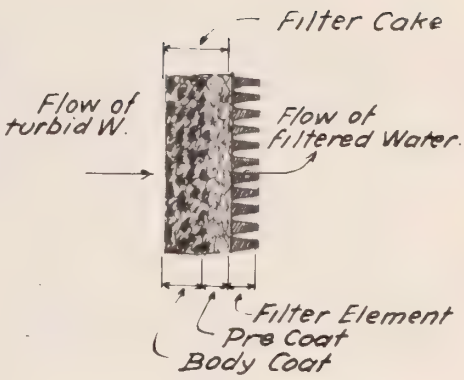


Fig. 2 Swimming Pool Diatomite Filter Plant

a - Raw water line b - Hair catcher. c - Recirculation pump. d - Filter. e - Filtered water line f - Slurry tank g - Sump Full arrows - normal flow. Dotted arrows - backwash flow.



ENLARGED SECTION OF FILTER MAT AND ELEMENT

Fig. 3 Detail of Septum

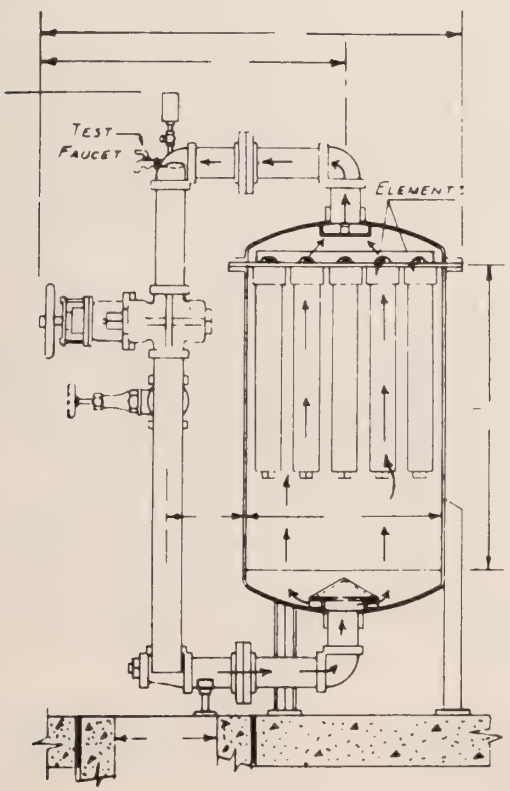


Fig. 4 Section of Filter

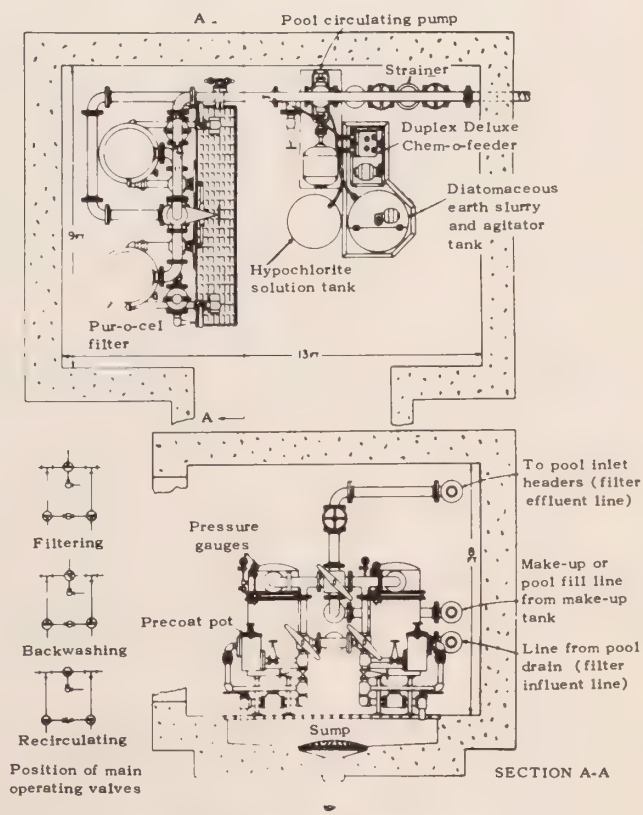


Fig. 5 Typical Swimming Pool Installation

B. Additional Electrical Safety Requirements for Outdoor Public Bathing Places

1. The crossing of outdoor public bathing places by open overhead electrical conductors is prohibited.

2. Overhead electrical conductors crossing playgrounds contiguous to outdoor public bathing places shall comply with the requirements of the National Electrical Safety Code, Part 2.

3. All metal fences or railings on which a broken electrical conductor might fall shall be effectively grounded. For this purpose driven ground rods shall be placed at two locations close to and on either side of each crossing. For parallel exposure exceeding 300 feet, additional grounds shall be provided at the midpoint, or at intervals not to exceed 300 feet.

C. Annual Electrical Safety Inspection

1. The electrical installation of every public bathing place should be inspected and approved annually by a reputable inspection agency for compliance with the foregoing requirements, and any violations reported shall be corrected promptly.

2. Any new or modified electrical installation of a public bathing place shall be inspected and, if necessary, corrected before it is placed in service, as provided in the preceding paragraph.

3. A record of each inspection and the recommendations made by the inspection agency shall be kept on file by the management for a period of at least two years.

Diatomaceous Earth Filters for Swimming Pools

The possibility of water filtration using diatomaceous earth as filter medium was known a quarter of a century ago. However, it was only during the last war, when the army needed compact filtering equipment which could be operated by inexperienced operators at a high filtration rate, that thousands of D. E. filtration plants were built and used. D. E. consists of the silicate shells of diatoms. This material is cleaned and processed and put on the market at the price of 3 to 4 cents per pound as a fine, white powder which is readily suspended in water and is manufactured in fine and coarser grade. It is mixed with water and deposited in a thin layer on the outer surface of cylindrically shaped, porous elements called "septa." These septa, Fig. 3, 4, project into the lower compartment of a cylindrical tank from a supporting metal plate at the upper tank level through which they penetrate. D. E. filtration consists of the raw water entering the lower tank, passing the D. E. layer into the inside of the septa, and being collected in the upper tank from where it is distributed in the system. Both tanks can be placed under high pressure - 50 to 75 lbs. per square inch. To make this possible the septa are made from spirally wound thin Monel metal bands or from porous aluminum oxide, or porous stainless steel castings. The outside of these cylinders are covered with a "precoat" of D. E., produced from a slurry pot placed directly beside each filter. The filter is then ready for operation. A suspension of D. E. is injected in the incoming stream and the D. E. particles mix with the turbidity particles in the water and are deposited on the outside of the pre-coat. This additional mix of D. E. is called the "body coat", and it accumulates on the outside of the septa until the pump pressure, needed to overcome the increased resistance, reaches the critical point. It is then necessary to backwash the filter. Backwashing is done by first closing the clear water outlet valve; then building up the pressure in the tank by compressing the air in the upper compartment; subsequently the raw water inlet valve is closed and the drain valve is opened. The water in the upper compartment will flow back through the septa and immediately break off the coatings on the outside which are wasted. This procedure uses only a few hundred gallons of water and is completed in 20 to 30 seconds. Subsequently the precoat is again applied which takes about four minutes. The total backwashing period lasts only eight to ten minutes. The amount of D. E. or "filter aid" varies; a 60,000 gallon pool with a turnover of 4, uses 20 lbs. of powder in 72 hours.

Because of the fact that (1) a much greater filter area can be developed inside the filters using the septa, and (2) the filter rate can be greatly increased up to 3 to 5 g. p. m. per square foot, as compared to 2 g. p. m. for rapid sand filters, therefore the same amount of water can be filtered in a much smaller space. A filter plant complete with 2 filters, slurry pots, recirculation pump, chemical feeder, D. E. body coat slurry agitator tank, and chlorinator needs only a space of 9 x 13 feet and has a maximum capacity of 250 g. p. m.

Against these greater advantages, should be mentioned the disadvantage of short filter runs i.e., 3 to 5 hours in some pools; the necessity of having great amounts of D. E. on hand to be used in emergencies; and the fact that precoats are subject to cracking and even breaking off, by

variations of pump pressure or otherwise, which makes close supervision necessary and enhances the necessity of chlorination of the effluent. For these reasons, these filters should be limited to swimming pools.

Regulations for Swimming Pools and Bathing Places

Every Sanitary Code should have regulations for swimming pools and bathing places. The foregoing recommendations contain practically all the pertinent scientific data available for drafting regulations. But first, certain key terms should be defined. These terms should include: Bathing place, artificial pool, fill and draw pool, semi-artificial pool, flowing-through pool, recirculation pool, natural bathing place, standard methods of water analyses, pool plumbing or bathing place plumbing, clean water, and person. These terms are all defined in the foregoing recommendations, except:

The term "Person" shall include any individual, firm corporation, association or partnership, institution, public body, or other entity, and shall include without reservation a private or public club, charitable organization, church organization, boys' organization, girls' organization and all such similar groups.

The term "clean water" shall mean new clean water used to refill the pool, new clean water used to replace loss by splashing or during cleaning the pool or water taken from the pool and returned after filtration or any combination of such water.

The term "pool plumbing" or "bathing place plumbing" shall mean and include any piping, conduit, open channel diversion device or waterway artifically constructed or installed for the purpose or bringing water from its source to a bathing place pool; all piping required for the introduction into or circulation through such pool; all collecting devices and drainage piping, conduit or channel required to circulate, treat, carry away or dispose of water from a pool starting at the point of delivery to the premises by a public or semipublic water system, or at the source if not delivered from a public or semipublic water system and including all equipment, treatment devices, pumps and appurtenances up to the point of discharge to a public or semipublic sewerage system, a point of legal discharge to a storm drain, drainage system, or natural water course. The term shall not include any portion of the building water supply system intended solely and exclusively for the purpose of furnishing water for drinking purposes or domestic use or normally accepted building use.

The regulations should:

1. Require that anyone wishing to construct, install, alter, extend or modify a bathing place must apply to the board of health for approval and must submit complete plans and specifications thereof with application for approval. If approval be issued, it should contain the terms and conditions of compliance with the sanitary code.

2. Require that anyone wishing to operate a bathing place must have an unrevoked permit from the board of health, posted in a conspicuous place.

3. State the limit required for compliance beyond which the permit is suspended and revoked. It should define the operators responsibilities in protecting the bathers, in providing competent operating personnel and safety attendants, and proper maintenance.

4. Require that the board of health make surveys, investigations and visits, should collect water samples, and should review laboratory reports as may be necessary to determine compliance.

5. Require that every permit holder furnish such records and information as are required by the board of health, such as records of chemicals added, filter operation, cleaning, bathing load. equipment operation, free chlorine residual, and attendance.

6. State the requirements of layout and arrangement of entrances and exits in relation to dressing rooms, showers, toilets, males and females, shallow and deep portions of pool; of adequacy of space and accessibility of filters, recirculation piping inlet and outlet valves, and all

treatment appurtenances for recirculation type pools; of location and ventilation of room containing liquid chlorine containers and equipment, and electrical safety requirements.

7. Require that the design and construction of new bathing places, and that the chemical, physical, and bacteriological quality of all pool water comply with the standards and requirements recommended by the American Public Health Association.

8. Require that the operating procedures for bathing places be in conformance with the recommendations of the American Public Health Association lest the permit to operate be suspended. These operating procedures for which minimum compliance should be stated in the regulations should relate to the following items: Visible dirt on bottom of pool, visible floating scum on surface of pool water, the bathing load, disinfection of pool water and testing and record of same; trained life guards and first aid attendants; the cleanliness, safeness, and sanitary maintenance of dressing rooms, hallways, toilet rooms, shower rooms; provision for sex separation in bath houses; the material construction, and finish of dressing room floors, walls, partitions, lockers, furniture and appurtenances, foot baths; amount of showers, toilet facilities, lavatories, drinking fountains, lighting, ventilation, heating; separate space and galleries for spectators; cleanliness of towels, bathing suits, combs, brushes; construction, location, and safeness of diving boards, towers, and floats; the provision of safety precautions and safety apparatus such as poles, throwing ring buoys, life guard elevated seats, first aid kits, safety regulations posted in conspicuous places, guard lines separating shallow from deep water, boats, oars, prong type rowlocks, signs and markers indicating the limits of safe bathing; adequate lighting for night bathing, grappling irons; cleansing shower before entering pool, use of toilet before cleansing shower, checking of skin diseases by attendants; prohibition of spitting, spouting, blowing nose, boisterous or rough play, and solo bathing.

9. Require that all business concessions in connection with bathing places comply with all provisions of the sanitary code which regulate water supply, liquid waste disposal, food establishments and food handling, rodent and insect control, housing, safeguards and sanitary conveniences for employees, plumbing, garbage, refuse, waste,rubbish, trash, and nuisances.

10. Establish a classification of safeness of natural bathing places based on recommendations of the American Public Health Association.

11. Require that wading pools be subject to all standards and requirements for bathing places unless specifically exempted. Wading pools not connected in any way with a bathing place, but operated under supervision in a public place, park playground, recreation center or other such place for the exclusive use of children under 10 years of age should conform with exemptions established for the wading pool on the basis of individual investigation. Such exemptions should be stated in writing as a part of the terms and conditions of the operating permit. Under no circumstances should the following minimum requirements be exempted: a) Water shall be furnished in a continuous flow while the wading pool is in use or intended to be used, or open for use, and the in-flowing water shall have a free chlorine residual of at least 0.5 ppm; b) all such wading pool water shall be wasted from the pool and under no circumstances shall such water be recirculated or reused; c) all such pools shall be cleaned, scrubbed, or disinfected each day prior to use; d) wading pools shall be surrounded with a walk-way not less than 4 feet in width which shall drain away from the pool to floor drains, properly trapped, and connected to a drain, and no walk-way drainage shall flow into the pool or into a drain whereby it can reach the pool as backflow.

Note: Control of Swimmer's Itch. This dermatitis is prevalent among bathers in lakes of the North Central part of the United States. It is caused by the larvae of schistosomes of lower animals which do not produce schistosomiasis in humans but do penetrate the skin causing a dermatitis. The worms die in the skin. The schistosomes may occur in waters which support snails (the intermediary host). Application of 2 pounds of copper carbonate, uniformly distributed per 1,000 sq. ft. of area, in lakes where the alkalinity is 75 p.p.m. or less, or 1 pound of copper sulfate for corresponding area where the alkalinity is greater than 75 p.p.m. gives control for one season and frequently longer. The treatment off shore is carried out to the 4 or 5 foot depth level and by treating upwind 100 to 200 ft. from the bathing beach as well as the beach itself.

Chapter XIII

Plumbing

Society has developed no more basic adjunct to health protection, especially in the areas of population concentration, than the technology of piping potable water into dwellings and draining away the wastes. Plumbing is the circulatory system of civilized men's dwelling units - a system which must function effectively lest society continue to be plagued by periodic convulsions of epidemic eruptions. Good public health practice requires that the plumbing of a community be free of cross-connections, back-flow connections, poor venting, and that it be maintained in a state of good repair for the sanitary intake of water and the sanitary drainage of liquid wastes. One of the important jobs of a sanitarian is the inspection of plumbing. There are few places in our country where adequate plumbing inspection and correction programs have operated effectively enough to eliminate the existing back-siphonage hazards. Who knows but that many of the unexplainable enteric and other epidemics constantly occurring in circumscribed areas may not be due to such defects in the plumbing. A project, therefore, which every sanitarian must always be cognizant of undertaking in his jurisdiction is a community survey for detecting and eliminating all back-siphonage hazards in plumbing. Although very few such projects have been seriously undertaken, the time has come when such activity should be routine for the sanitarian. Understanding the principles of plumbing, therefore is basic to the knowledge of the sanitarian.

Basic Principles (Technical Committee on Plumbing Standards - U.S.P.H.S. 1962)

Principle No. 1. - All Occupied Premises Shall Have Potable Water: All premises intended for human habitation, occupancy, or use shall be provided with a supply of potable water. Such a water supply shall not be connected with unsafe water sources, nor shall it be subject to the hazards of backflow or back-siphonage.

Principle No. 2 - Adequate Water Required: Plumbing fixtures, devices, and appurtenances shall be supplied with water in sufficient volume and at pressures adequate to enable them to function properly and without undue noise under normal conditions of use.

Principle No. 3 - Hot Water Required: Hot water shall be supplied to all plumbing fixtures which normally need or require hot water for their proper use and function.

Principle No. 4 - Water Conservation: Plumbing shall be designed and adjusted to use the minimum quantity of water consistent with proper performance and cleaning.

Principle No. 5 - Dangers of Explosion or Overheating: Devices for heating and storing water shall be so designed and installed as to guard against dangers from explosion or overheating.

Principle No. 6 - Use Public Sewer Where Available: Every building with installed plumbing fixtures and intended for human habitation, occupancy, or use, and located on premises where a public sewer is on or passes said premises within a reasonable distance, shall be connected to the sewer.

Principle No. 7 - Required Plumbing Fixtures: Each family dwelling unit shall have at least one water closet, one lavatory, one kitchen-type sink, and one bathtub or shower to meet the basic requirements of sanitation and personal hygiene.

All other structures for habitation shall be equipped with sufficient sanitary facilities. Plumbing fixtures shall be made of durable, smooth, nonabsorbent and corrosion resistant material and shall be free from concealed fouling surfaces.

Principle No. 8 - Drainage system of Adequate Size: The drainage system shall be designed, constructed, and maintained to guard against fouling, deposit of solids, and clogging, and with adequate cleanouts so arranged that the pipes may be readily cleaned.

Principle No. 9 - The piping of the plumbing system shall be of durable material, free from defective workmanship and so designed and constructed as to give satisfactory service for its reasonable expected life.

Principle No. 10 - Liquid Sealed Traps Required: Each fixture directly connected to the drainage system shall be equipped with a liquid-seal trap.

Principle No. 11 - Trap Seals Shall be Protected: The drainage system shall be designed to provide an adequate circulation of air in all pipes with no danger of siphonage, aspiration, or forcing of trap seals under conditions of ordinary use.

Principle No. 12 - Exhaust Foul Air to Outside: Each vent terminal shall extend to the outer air and be so installed as to minimize the possibilities of clogging and the return of foul air to the building.

Principle No. 13 - Test the Plumbing System: The plumbing system shall be subjected to such tests as will effectively disclose all leaks and defects in the work or the material.

Principle No. 14 - Exclude Certain Substances From the Plumbing System: No substance which will clog or accentuate clogging of pipes, produce explosive mixtures, destroy the pipes or their joints, or interfere unduly with the sewage-disposal process shall be allowed to enter the building drainage system.

Principle No. 15 - Prevent Contamination: Proper protection shall be provided to prevent contamination of food, water, sterile goods, and similar materials by backflow of sewage. When necessary, the fixture, device, or appliance shall be connected indirectly with the building drainage system.

Principle No. 16 - Light and Ventilation: No water closet or similar fixture shall be located in a room or compartment which is not properly lighted and ventilated.

Principle No. 17 - Individual Sewage Disposal Systems: If water closets or other plumbing fixtures are installed in buildings where there is no sewer within a reasonable distance, suitable provision shall be made for disposing of the sewage by some accepted method of sewage treatment and disposal.

Principle No. 18 - Prevent Sewer Flooding: Where a plumbing drainage system is subject to backflow of sewage from the public sewer, suitable provision shall be made to prevent its overflow in the building.

Principle No. 19 - Proper Maintenance: Plumbing systems shall be maintained in a safe and serviceable condition from the standpoint of both mechanics and health.

Principle No. 20 - Fixtures shall be Accessible: All plumbing fixtures shall be so installed with regard to spacing as to be accessible for their intended use and cleansing.

Principle No. 21 - Structural Safety: Plumbing shall be installed with due regard to preservation of the strength of structural members and prevention of damage to walls and other surfaces through fixture usage.

Principle No. 22 - Protect Ground and Surface Water: Sewage or other waste shall not be discharged into surface or subsurface water unless it has first been subject to some acceptable form of treatment.

Plumbing System

The plumbing system of a building is a system of pipes including the water service line and building drainage lines from their several connections within the building to their connections with the public mains or individual water supply and sewage disposal systems, together with fixtures, traps, vents, and other devices connected thereto. Storm water drainage pipes may be considered a part of the plumbing system when connected to a public sewer system.

The house or building plumbing is the beginning of the town drainage system and the termination of its water distributing system. It brings the water supply into the building and collects the waste materials from toilet, washbowl, bath tub, kitchen sink, laundry tray and other fixtures. More and more, liquid waste from the kitchen has come to include pulverized garbage.

The Main Features of Sanitary Plumbing are:

1. The vertical pipe lines:
   a. One or more vertical drainage stacks - these extend from below the lowest fixture to the roof and collect the wastes from plumbing fixtures.
   b. One or more vertical water supply pipes - these arise from the underground lead-in coming from the street main and serve to distribute the water to various levels in the building.
2. The horizontal pipe lines:
   a. The house drain which runs horizontally under the ground and receives the discharge from the drainage stack, conveying it to the house sewer which empties into the street sewer.
   b. The lead-in water line from the street water main which supplies vertical water pipes in the building, or a water tank placed on the roof, which in turn provides the building with water.

Definitions

Air Break (Drainage System): A piping arrangement in which a drain from a fixture, appliance, or device discharges indirectly into a fixture, receptacle, or interceptor at a point below the flood level rim of the receptacle.

Air Gap (Drainage System): The unobstructed vertical distance through the free atmosphere between the outlet of waste pipe and the flood level rim of the receptacle into which it is discharging.

Air Gap (Water Distribution System): The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture or other device and the flood level rim of the receptacle.

Anchors: Devices for supporting and securing pipe, fixtures, and equipment. (See Supports.)

Area Drain: A receptacle designed to collect surface or storm water from an open area.

Auxiliary Supply: Any water source or system other than the city water supply which may be available in the building or premises.

Backflow: The flow of water or other liquids, mixtures or substances into the distributing pipes of a potable supply of water from any source or sources other than its intended source. Back-siphonage is one type of backflow.

Backflow Connection: Any arrangement whereby backflow can occur.

Backflow Preventer: A device or means to prevent backflow.

Backflow Preventer, Reduced Pressure Zone Type: An assembly of differential valves and check valves including an automatically opened spillage port to the atmosphere.

Back-Siphonage: The flowing back of used, contaminated, or polluted water from a plumbing fixture or vessel or other sources into a water supply pipe due to a negative pressure in such pipe.

Barometric Loop: A loop of pipe rising approximately 35 feet, at its topmost point, above the highest fixture it supplies.

Battery of Fixtures: Any group of two or more similar adjacent fixtures which discharge into a common horizontal waste or soil branch.

Boiler Blow-Off: An outlet on a boiler to permit emptying or discharge of sediment.

Boiler Blow-Off Tank: A vessel designed to receive the discharge from a boiler blow-off outlet and to cool the discharge to a temperature which permits its safe discharge to the drainage system.

Branch: Any part of the piping system other than a main or stack.

Branch, Fixture: See Fixture Branch.

Branch Horizontal: See Horizontal Branch.

Branch Interval: A distance along a soil or waste stack corresponding in general to a story height, but in no case less than 8 feet, within which the horizontal branches from one floor or story of a building are connected to the stack.

Branch Vent: A vent connecting one or more individual vents with a vent stack or stack vent.

Building Drain: That part of the lowest piping of a drainage system which receives the discharge from soil, waste, and other drainage pipes inside the walls of the building and conveys it to the building sewer beginning 3 feet outside the building wall.

Building Drain — Combined: A building drain which conveys both sewage and storm water or other drainage.

Building Drain - Sanitary: A building drain which conveys sewage only.

Building Drain - Storm: A building drain which conveys storm water or other drainage but no sewage.

Building Sewer: That part of the drainage system which extends from the end of the building drain and conveys its discharge to a public sewer, private sewer, individual sewage-disposal system, or other point of disposal.

Building Sewer - Combined: A building sewer which conveys both sewage and storm water or other drainage.

Building Sewer - Sanitary: A building sewer which conveys sewage only.

Building Sewer - Storm: A building sewer which conveys storm water or other drainage but no sewage.

Building Subdrain: That portion of a drainage system which cannot drain by gravity into the building sewer.

Building Trap: A device, fitting, or assembly of fittings installed in the building drain to prevent circulation of air between the drainage system of the building and the building sewer.

Cesspool: A lined and covered excavation in the ground which receives the discharge of domestic sewage or other organic wastes from a drainage system, so designed as to retain the organic matter and solids, but permitting the liquids to seep through the bottom and sides.

Check Valve: An automatically operated device which is designed to permit the flow of fluids in one direction and to close if there be a reversal of flow.

Circuit Vent: A branch vent that serves two or more traps and extends from the down-stream side of the highest fixture connection of a horizontal branch to the vent stack.

Combination of Fixture: A fixture combining one sink and laundry tray or a two or three-compartment sink or laundry tray in one unit.

Combined Building Drain: See Building Drain-Combined.

Combined Building Sewer: See Building Sewer-Combined.

Combination Waste and Vent System: A specially designed system of waste piping embodying the horizontal wet venting of one or more sinks or floor drains by means of a common waste and vent pipe adequately sized to provide free movement of air above the flow line of the drain.

Common Vent: A vent connecting at the junction of two fixture drains and serving as a vent for both fixture and drains.

Conductor: A pipe inside the building which conveys storm water from the roof to a storm or combined building drain.

Continuous Vent: A vertical vent that is a continuation of the drain to which it connects.

Continuous Waste: A drain from two or more fixtures connected to a single trap.

Cross Connection: Any physical connection or arrangement between two otherwise separate piping systems, one of which contains potable water and the other either water of unknown or questionable safety or stream, gas, or chemical whereby there may be a flow from one system to the other, the direction of flow depending on the pressure differential between the two systems. (See Backflow and Back-Siphonage.)

Dead End: A branch leading from a soil, waste, or vent pipe, building drain, or building sewer, and terminating at a developed length of 2 feet or more by means of a plug, cap, or other closed fitting.

Developed Length: The length of a pipe line measured along the center line of the pipe or fittings.

Double Offset: Two changes of direction installed in success or series in a continuous pipe.

Downspout: An exterior drainage pipe for conveying storm water from roof or gutter drains.

Domestic Sewage: The water-borne wastes derived from ordinary living processes.

Drain: Any pipe which carries waste water or water-borne wastes in a building drainage system.

Drainage Pipe: See Drainage System.

Drainage System: Includes all the piping, within public or private premises, which conveys sewage, rain water, or other liquid wastes to a legal point of disposal. It does not include the mains of a public sewer system or private or public sewage-treatment or disposal plant.

Building Gravity Drainage System: A drainage system which drains by gravity into the building sewer.

Sub-Building Drainage System: See Building Subdrain.

Dry Well: See Leaching Well.

Dual Vent: See Common Vent.

Durham System: A term used to describe soil or waste system where all piping is of threaded pipe, tubing, or other such rigid construction, using recessed drainage fittings to correspond to the types of piping.

Effective Opening: The minimum cross-sectional area at the point of water supply discharge,

measured or expressed in terms of (1) diameter of a circle, or (2) if the opening be not circular, the diameter of a circle of equivalent cross-sectional area.

Existing Work: A plumbing system or any part thereof installed prior to the effective date of this Code.

Fire Line: A system of pipes and equipment used exclusively to supply water for extinguishing fires.

Fixture: See Plumbing Fixture.

Fixture Branch: A pipe connecting several fixtures.

Fixture Drain: The drain from the trap of a fixture to the junction of that drain with any other drain pipe.

Fixture Supply: The water supply pipe connecting a fixture to a branch water supply pipe or directly to a main water supply pipe.

Fixture Unit (Drainage-d.f.u.): A common measure of the probable discharge into the drainage system by various types of plumbing fixtures. The drainage fixture-unit value for a particular fixture depends on its volume rate of drainage discharge, on the time duration of a single drainage operation, and on the average time between successive operations.

Fixtures Unit (Supply-s.f.u.): A common measure of the probable hydraulic demand on the water supply by various types of plumbing fixtures. The supply fixture-unit value for a particular fixture depends on its volume rate of supply, on the time duration of a single supply operation, and on the average time between successive operations.

Flood Level: See Flood Level Rim.

Flood Level Rim: The edge of the receptacle from which water overflows.

Flooded: When the liquid in a fixture or receptacle rises to the flood-level rim.

Flood Pressure: The pressure in the water supply pipe near the faucet or water outlet while the faucet or water outlet is wide-open and flowing.

Flush Valve: A device located at the bottom of tank for flushing water closets and similar fixtures.

Flushometer Valve: A device which discharges a predetermined quantity of water to fixtures for flushing purposes and is actuated by direct water pressure.

Frostproof Closet: A hopper with no water in the bowl and with the trap and water supply control valve located below frost line.

Fume Pipe: A conduit connecting a fuel burning appliance with the chimney flue.

Grade: The fall (slope) of a line of pipe in reference to a horizontal plane. In drainage it is usually expressed as the fall in a fraction of an inch per foot length of pipe.

Grease Interceptor: See Interceptor.

Grease Trap: See Interceptor.

Hangers: See Supports.

Horizontal Branch Drain: A drain branch pipe extending laterally from a soil or waste stack or building drain, with or without vertical sections or branches, which receives the discharge

from one or more fixture drains and conducts it to the soil or waste stack or to the building drain.

Horizontal Pipe: Any pipe or fitting which makes an angle of less than 45^{o} with the horizontal.

Hot Water: Water at a temperature of not less than 120^{o} F.

House Drain: See Building Drain.

House Sewer: See Building Sewer.

House Trap: See Building Trap.

Hydropneumatic Tank: A pressure vessel in which air pressure acts upon the surface of the water contained within the vessel, pressurizing the water distribution piping connected to the vessel.

Individual Sewage Disposal System: A system for disposal of domestic sewage by means of a septic tank, cesspool or mechanical treatment, designed for use apart from a public sewer to serve a single establishment or building.

Indirect Waste Pipe: A waste pipe which does not connect directly with the drainage system, but which discharges into the drainage system through an air break or air gap into a trap, fixture, receptacle or interceptor.

Individual Vent: A pipe installed to vent a fixture drain. It connects with the vent system above the fixture served or terminated outside the building into the open air.

Individual Water Supply: A supply other than an approved public water supply which serves one or more families.

Industrial Wastes: Liquid wastes resulting from the processes employed in industrial and commercial establishments.

Inlet: The open end of the water supply pipe through which the water is discharged into the plumbing fixture.

Interceptor: A device designed and installed so as to separate and retain deleterious, hazardous, or undesirable matter from normal wastes while permitting normal sewage or liquid wastes to discharge into the drainage system by gravity.

Leaching Well or Pit: A pit or receptacle having porous walls which permit the contents to seep into the ground.

Leader: See Downspout.

Liquid Waste: The discharge from any fixture, appliance, area or appurtenance, which does not contain fecal matter.

Load Factor: The percentage of the total connected fixture unit flow which is likely to occur at any point in the drainage system. It varies with the type of occupancy, the total flow unit above this point being considered, and with the probability factor of the simultaneous use.

Local Ventilating Pipe: A pipe on the fixture side of the trap through which vapor or foul air is removed from a room or fixture.

Loop Vent: A circuit vent which loops back to connect with a stack vent instead of a vent stack.

Main: The principal pipe artery to which branches may be connected.

Main Sewer: See Public Sewer.

Main Vent: A principal artery of the venting system to which vent branches may be connected.

Offset: A combination of elbows or bends which brings one section of the pipe out of line but into a line parallel with the other section.

Pitch: See Grade.

Plumbing: The practice, materials, and fixtures used in the installation, maintenance, extension, and alteration of all piping, fixtures, appliances, and appurtenances in connection with any of the following: Sanitary drainage or storm drainage facilities, the venting system and the public or private water supply systems, within or adjacent to any building structure, or conveyance; also the practice and materials used in the installation, maintenance, extension, or alteration of storm water, liquid waste, or sewerage, and water supply systems of any premises to their connection with the public sewer system or other acceptable disposal facility.

Plumbing Fixture: Installed receptacles, devices, or appliances either supplied with water or receive or discharge liquids, or liquid-borne wastes, or both.

Plumbing System: Includes the water supply and distribution pipes, plumbing fixtures and traps; soil, waste, and vent pipes; building drains and building sewers including their respective connections, devices, and appurtenances within the property lines of the premises, and water treating or water using equipment.

Potable Water: Water free from impurities present in amounts sufficient to cause disease or harmful physiological effects. Its bacteriological and chemical quality shall conform to the requirements of the Public Health Service Drinking Water Standards or the regulations of the public health authority having jurisdiction.

Private or Private Use: In the classification of plumbing fixtures, private applies to fixtures in residences and apartments and to fixtures in private bathrooms of hotels as well as similar installations in other buildings where the fixtures are intended for the use of a family or an individual.

Private Sewer: A sewer, serving two or more buildings, privately owned, and not directly controlled by public authority.

Public or Public Use: In the classification of plumbing fixtures, public applies to fixtures in general toilet rooms of schools, gymnasiums, hotels, railroad stations, public buildings, bars, public comfort stations, and other installations (whether pay or free) where a number of fixtures are installed so that their use is similarly unrestricted.

Public Sewer: A common sewer directly controlled by public authority.

Public Water Main: A water supply pipe for public use controlled by public authority.

Receptor: A fixture or device which receives the discharge from indirect waste pipes.

Relief Vent: A vent so planned as to permit additional circulation of air between drainage and vent systems.

Return Offset: A double offset installed so as to return the pipe to its original alignment.

Revent Pipe: See Individual Vent.

Rim: An unobstructed open edge of a fixture.

Riser: A water supply pipe which extends vertically one full story or more to convey water to branches or to a group of fixtures.

Roof Drain: A drain installed to receive water collecting on the surface of a roof and to discharge it into a leader or a conductor.

Roughing-In: The installation of all parts of the plumbing system which can be completed prior to the installation of fixtures. This includes drainage, water supply, and vent piping, and the necessary fixture supports.

Safe Waste: See Indirect Waste.

Sand Interceptor: See Interceptor.

Sand Trap: See Interceptor.

Sanitary Sewer: A pipe which carries sewage and excludes storm, surface, and ground water.

Seepage Well or Pit: A covered pit with open-jointed lining through which the septic tank effluent it received may seep or leach into the surrounding porous soil.

Separator: See Interceptor.

Septic Tank: A water-tight receptacle which receives the discharge of a building sanitary drainage system or part thereof, and is designed and constructed so as to separate solids from the liquid, digest organic matter through a period of detention, and allow the liquids to discharge into the soil outside of the tank through a system or open joint or perforated piping, or a seepage pit.

Sewage: Any liquid waste containing animal or vegetable matter in suspension or solution, and may include liquids containing chemicals in solution.

Sewage Ejectors: A device for moving sewage by entraining it in a high velocity steam, air or water jet.

Side Vent: A vent connecting to the drain pipe through a fitting at an angle not greater than 45^{o} to the vertical.

Size of Pipe and Tubing: See Diameter.

Slope: See Grade.

Soil Pipe: A pipe which conveys sewage containing fecal matter to the building drain or building sewer.

Soil Vent: See Stack Vent.

Special Wastes: Wastes which require special treatment before entry into the normal plumbing system.

Special Waste Pipe: Pipes which convey special wastes.

Stack: A general term for any vertical line of soil, waste, or inside conductor piping. This does not include vertical fixture and vent branches which do not extend through the roof or which pass through less than two stories before being reconnected to a vent stack or stack vent.

Stack Group: A group of fixtures located adjacent to the stack so that by means of proper fittings, vents may be reduced to a minimum.

Stack Vent: The extension of a soil or waste stack above the highest horizontal drain connected to the stack.

Stack Venting: A method of venting a fixture or fixtures through the soil or waste stack.

Storm Drain: See Building Storm Drain.

Storm Sewer: A sewer used for conveying rain water, surface water, condensate, cooling water, or similar liquid wastes.

Subsoil Drain: A drain which collects subsurface or seepage water and conveys it to a place of disposal.

Sump: A tank or pit, which receives sewage or liquid waste, located below the normal grade of the gravity system and which must be emptied by mechanical means.

Sump Pump: A mechanical device other than an ejector or bucket for removing sewage or liquid waste from a sump.

Supports: See Anchors.

Surge Tank: The receiving, non-pressure vessel forming part of the air gap separation between a potable and an auxiliary supply.

Swimming Pool: Any structure, basin, chamber, or tank containing an artificial body of water for swimming, diving, or recreational bathing and having a depth of two feet or more at any point.

Trap: A fitting or device which provides a liquid seal to prevent the emission of sewer gases without materially affecting the flow of sewage or waste water through it.

Trap Seal: The vertical distance between the crown weir and the top of the dip of the trap.

Vacuum: Any pressure less than that exerted by the atmosphere.

Vacuum Breaker: See Backflow Preventer.

Vacuum Breaker, Non-Pressure Type (Atmospheric): A vacuum breaker which is not designed to be subjected to static line pressure.

Vacuum Breaker, Pressure Type: A vacuum breaker designed to operate under conditions of static line pressure.

Vent Connector: See Fume Pipe.

Vent Pipe: Part of the vent system.

Vent Stack: A vertical vent pipe installed to provide circulation of air to and from the drainage system.

Vent System: A pipe or pipes installed to provide a flow of air to or from a drainage system or to provide a circulation of air within such system to protect trap seals from siphonage and back pressure.

Vertical Pipe: Any pipe or fitting which makes an angle of 45^{o} or less with the vertical.

Wall Hung Water Closet: A wall mounted water closet installed in such a way that no part of the water closet touches the floor.

Waste: Liquid Waste and industrial waste.

Waste Pipe: A pipe which conveys only waste.

Water Distributing Pipe: A pipe within the building or on the premises which conveys water from the water-service pipe to the point of usage.

Water Lifts: See Sewage Ejector.

Water Main: A water supply pipe for public use.

Water Outlet: A discharge opening through which water is supplied to a fixture, into the atmosphere (except into an open tank which is part of the water supply system), to a boiler or heating system, to any devices or equipment requiring water to operate but which are not part of the plumbing system.

Water Riser Pipe: See Riser.

Water Service Pipe: The pipe from the water main or other source of water supply to the water distributing system of the building served.

Water Supply System: The water service pipe, the water-distributing pipes, and the necessary connecting pipes, fittings, control valves, and all appurtenances in or adjacent to the building or premises.

Yoke Vent: A pipe connecting upward from a soil or waste stack to a vent stack for the purpose of preventing pressure changes in the stack.

Conditions Which May Cause Contamination

These conditions can be broadly divided into three classes:

1. Decreased pressure in the water distributing system,
2. Increased pressure in the drainage systems,
3. Defects in structure of fixtures, appliances and equipment,
    a. Leaks,
    b. Open top water supply and storage tanks,
    c. Inadequate heating facilities in sterilizing equipment,

These may all operate at the same time. More specifically these conditions may be described as follows:

1. Those due to development of negative pressure in water distributing lines.

a. Water pressure fluctuates for various reasons and may become negative at any point in the water-supply distribution system.

b. A water inlet which terminates below the spill-line of a receptacle may at some time become submerged, thus making possible the back-siphonage of the contents of the receptacles or fixtures into the water pipe.

c. A partial vacuum may be created when steam condenses in a closed vessel, when the water flows through a constricted area in the pipe, and when other causes of partial vacuum are present. (See below.)

d. Many water closets and certain other fixtures that are equipped with flushometer valves constitute a direct connection system between the water supply and the plumbing drainage system and may permit back-siphonage of the contents of the fixtures unless they be equipped with effective vacuum breakers.

2. Those due to the building up of positive pressure in the drainage system.

e. Pressures may develop in street sewers, building drains, and waste pipes because of stoppage, air locks, or overloading.

3. Those due to leaks.

f. Water pipes may leak and pollute sterile water, utensils, bandages, and other sterile objects.

g. Valves and checks, even tho closed, may leak, and are therefore not equivalent to a complete physical break.

h. Pipes that carry sewage contaminated water, or poisonous liquids are occasionally located in such a way that leakage from them may cause contamination of water, food, dishes, cutlery, etc.

4. Those due to inadequate heating facilities in sterilizing equipment.

i. Another condition not associated with water movement which may cause contamination is when water in hot-water lines may not always be maintained at temperatures high enough to sterilize water.

Common Causes of a Partial Vacuum

1. Shutting off a portion of a system and draining it for repairs.

2. A break which drains portions of a piping system.

3. Heavy demands, causing water to be drawn from higher elevations of a piping system.

4. Too many outlets on an undersized piping system.

5. Fire engines pumping from the system, or pumps in the system used for booster purposes which reduce pressure below normal.

6. Draining the pipe lines for cleaning and flushing them.

How the Water Supply May Become Contaminated by Waste Waters

Sewage, being a relatively dilute mixture of numerous kinds of wastes from household and industry, must at some point receive the water of which it is composed. It is because water and waste must have a common meeting place in order to become sewage, that we must guard carefully lest the continuous cycle of incoming water and outgoing sewage be not reversed. The reversal of this cycle is possible due to the peculiar character of water and sewage systems and in particular of the appliances to which they are connected. The water system is a closed system of pipes from the water main at the purification plant to the faucet in the home. The sewage system is a closed system of pipes from the waste receptacle to the sewage disposal plant, or sewage receiving body of water. More or less it can be said that where one system begins the other ends, and where one ends the other begins. Because of the close relationship of these two systems we may even consider them as two parts of one large system - the sewerage part as the outgoing phase and the water distributing part as the in-going phase. In order for this system to function adequately in so far as our health is concerned, it becomes imperative that the direction of the cycle does not become reversed. At the sewage disposal end we guard against sewage becoming water supply by treating

sewage at disposal plants and treating water at purification plants. At the water consuming end we must guard against sewage becoming water supply by installation of plumbing which will prevent the back flow of sewage into the water supply. Thus, the two systems must be kept open only at their terminals, since, if the two systems joined each other at their terminals into a closed system or at any intermediate point, any great enough increase in the pressure in the sewerage system or decreased pressure in the water system would cause a reversal in the flow of the liquid with contamination of the water supply.

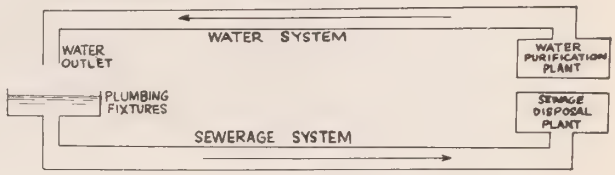


Fig. 1. Safe System for Sewage and Water (Open at each Terminal). In such a system a reversal in flow would not contaminate the water since there is no direct connection between water and sewage.

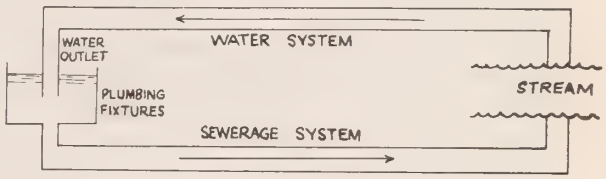


Fig. 2. Unsafe System for Sewage and Water (Closed at each Terminal). In such a system a reversal in flow would draw sewage from the waste receptacle into the water supply system. Where the water and sewage remained untreated the system could be considered closed since the water supply system would draw in untreated sewage. This can easily be realized where the water is drawn from rivers and lakes. For the cases where well waters are used without any treatment, it should be remembered that they have been, in reality, treated by nature through purification in the soil.

Leaving water purification and sewage treatment to be discussed under other appropriate headings, our main source of water contamination at the other end of the system is inadequate plumbing which is unable to prevent the back flow of sewage into the water system when the pressure conditions within the pipe lines become upset. To understand clearly how such back flows are developed it becomes necessary to understand some of the principles of hydraulics. Hydraulics is the science which treats of the physical properties of water, both at rest and in motion. In plumbing we are concerned mainly with the movement of water in pipes due to pressures and counterpressures, or increased pressures and partial vacuums. Included here also is the principle of siphonage.

A vacuum means that air or gas is more or less completely absent. Under ordinary conditions there is a certain amount of atmosphere surrounding the earth. Since atmosphere is a combination of various gases, it has weight. Gases are composed of moving molecules. Therefore the weight of the gases is due to their material and their amount of movement (as indicated by temperature). For example, a cubic foot of air at sea-level weighs more when cold than when hot, and one cubic foot of carbon dioxide weighs more than one cubic foot of air under the same conditions. If one had the instruments for measuring the weight of the atmosphere on each square inch of earth surface at sea-level, it would be found to be 14.7 pounds. The higher the land the less the weight. This means, of course, that the atmosphere is pressing against the surface with a pressure of 14.7 pounds to every square inch at sea-level. This is called one atmospheric pressure. On most pressure gauges, one atmospheric pressure is calibrated to read zero. If the air were completely withdrawn from a long vertical pipe after the lower end was immersed in water, the water would rise in the pipe to a height of about 34 feet and no further. This means that the atmospheric pressure on the surface of the water is great enough to force the water into the pipe to a level of 34 ft.

If only part of the air were withdrawn from the pipe, then the water would rise less than 34 ft. Thus the degree of the vacuum or partial vacuum would determine how high the water would rise. If one were to do this experiment on the top of a high mountain, one would find that the atmospheric pressure would be less and therefore the water would not rise 34 ft. into the pipe.

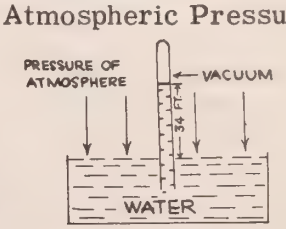


Fig. 3. Illustration of Atmospheric Pressure

Basic Physical Laws of the Flow of Water in the Water Distribution System

Direction of Flow

We all know, that in open channels, like ditches and rivers, water flows from a higher point to

a lower point; by "high" and "low" we mean the vertical distance to a level called "mean sea level." The flow is entirely due to gravity, i.e., to the weight of the water. In a system of pipes filled with water, the flow is, however, the result of difference of elevation and, in addition, the mechanical pressure. This pressure can overcome the gravity and the water can flow upward from a lower level to a higher one. The pressure due to gravity alone amounts to 0.434 lbs. per square inch for every foot of height of water, if the water be at rest. In wide pipes with water in slow motion, this is also true, but in smaller pipes with greater velocities there will be a pressure loss due to friction. This loss is called "loss of head." For instance, in a stand-pipe connecting with an elevated tank in which the water level is 100 feet high, the pressure at the bottom of the stand-pipe will be 100 x 0.434 = 43.4 pounds per square inch. At this point there will be a water main leading to a distribution system. If the pressure be measured a mile away it may be found to be only 35 pounds; and in the water tap at the home only 20 pounds. These losses of pressure are due to friction between the water and the pipes, and they increase sharply when the pipe size decreases and the velocity of the water increases.

When we follow a drop of water from the top of the tank to the faucet, then we see that when it started it had a zero pressure, and at the bottom of the stand-pipe a pressure of about 43 pounds, and at the faucet, 20 pounds; when we catch it in a bucket the pressure will be again zero. To say that water flows from a greater pressure to a lesser one, in this case, would be wrong. What happened here is that the water, with all kinds of pressures, flowed from a higher altitude to a lower one. But if we had to provide the top floor of a 10 story building with water, we would need a booster pump in the basement to add mechanical pressure to the 20 pounds of gravity pressure left; the water would then flow from a higher pressure to a lesser one, but also from a lower level to a higher one. Moreover it should be realized that, apart from friction losses, the mechanical pressure remains the same, whereas the gravity pressure varies directly with the elevation; also that the mere fact of elevation, even with a zero pressure, is a great factor in water supplies. This more or less complicated matter becomes much easier to understand if we were to provide the pipes with little holes in which vertical glass tubes were to be fixed so that the water could rise in accordance with the pressure at that point. The line which would connect the water levels in the tubes is called the hydraulic grade line or gradient (see Fig. 4). The following rule then applies:

The direction of flow in a pipe line is from a higher point in the hydraulic gradient to a lower point, no matter if the pipe be horizontal, vertical or sloping. To illustrate this, let us take a horizontal line for reference and show various pipe sections under various conditions while observing the water levels in the vertical glass tubes as explained above: (Figure 4).

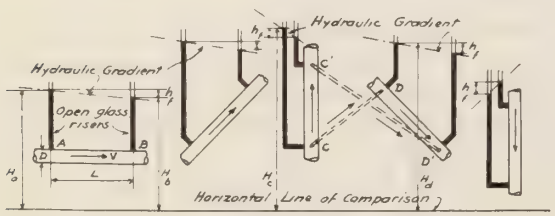


Fig. 4. Hydraulic Gradient & Direction of Flow

If for the various pipe sections shown the length L between glass riser tubes, pipe diameter D and water velocity V are the same, friction loss h_f will remain the same no matter position or location of pipe

The flow in these pipe sections will be as indicated by the arrows. If, for instance, a pipe connection were made between points C and D of the two pipes, the water would flow by gravity from C to D because Hc is greater than Hd.

When two pipes are in the same horizontal plane so that the force of gravity is in equilibrium, then if a connection be made, the water will run from the pipe with the higher pressure to that with the lower one. (Figure 5).

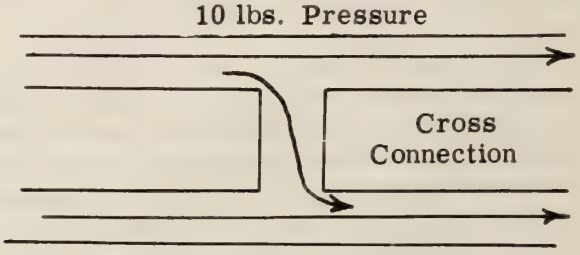


Fig. 5

It has already been stated that pressure in a pipe can be greatly decreased because of friction loss. Two pipes under entirely equal conditions originally, but with an excessive flow of water in one of them, (Fig. 6) may create a difference of pressure as snown above and even a partial vacuum may be created in one of them, because of a burr, corrosions, or other sudden constriction in the passageway of the pipe. In that case water could be sucked from one pipe to another, causing a cross connection. (It should be remarked here that a valve in the connecting line is not considered a proper preventive against

such an occurrence, as most valves leak sufficiently to allow contamination by bacteria. In some states even double check valves are not allowed).

Siphonage

Another physical law which must be observed is that known as siphonage. If a flexible tube be filled with water and stoppered at both ends, then inverted and one end submerged in a basin of water and the stopper removed, while the other end is brought at a level below that of the water, the water will flow out of the basin and through the hose as soon as the stopper at the lower end is removed. To explain this well known phenomenon, let us study the situation first before the removal of the second stopper.

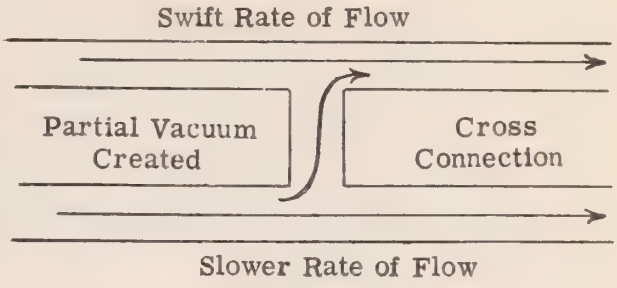


Fig. 6

When an object is at rest it is because of the fact that the forces acting on that object are in equilibrium. Consider a heavy object placed on a table. It will not move because the force of gravity (weight) acting on the object is in equilibrium with the force (reaction) which the object receives from the table. Place the same object on a pillow resting on the table, it will sink down in the pillow until the stuffing is solid enough to carry the weight to the table and also transmit the reacting force from the table.

Now, let us put some water into a basin and consider one square inch layer of surface of that water which is so thin that its weight would be negligible. It does not move, therefore, it is in equilibrium under the forces acting upon it, to wit, the air pressure of 1 atmosphere pressing downward, and the reaction force of 1 atmosphere by the underlying water, acting upward.

There is a law in physics which predicates that in a body of water (or a mass of fluid) at rest, the pressure per square inch is the same everywhere.

In figure 7 the water pressure is then 1 atmosphere at E, A and D, upward and downward. At B, however, on the top of the stopper, the pressure will be increased by the weight of the column of water (H-h) for every square inch. If we assume that the column of water (H-h) be 1 lb., and 1 atmosphere be 14 1/2 lbs., then at A and D the pressure is 14 1/2 lbs., and at B 15 1/2 lbs. This pressure of 15 1/2 lbs. is carried by the stopper, which, in turn, receives an upward push of 14 1/2 lbs. from the air (the difference being transmitted to the walls of the tube.)

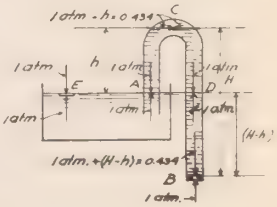


Fig. 7. Siphon

The stopper at B is removed. The outside air can provide only a pressure of 14 1/2 lbs., therefore, the pressure at D is 14 1/2 - 1 (the weight of the column of water, H-h) = 13 1/2 lbs. The column of water (H-h) will start to fall and the water will flow from the higher pressure at A to the lower pressure at D. The partial vacuum will be highest at C, this being the highest point in the tube. The flow will continue until the water level has fallen below one of the two open ends of the tube.

Fundamentals of flow through drain pipes

The drain system has the function to remove the wastes from sinks and fixtures with reasonable speed and without noise, and protect the air in the rooms against odors and gasses. The latter is accomplished by the use of traps or water seals which prevent the air from the drain system entering the building. In a P trap (see Fig. 8) the seal is obtained by the distance A B between the invert of the drain pipe and the crown of the bend; only 2 inches is needed for this purpose. In a water closet it is the distance between the overflow level of the closet bowl and the bottom of the baffle placed in the bowl.

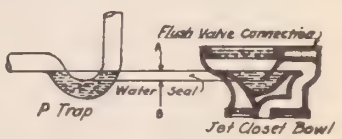


Fig. 8. The Water Seal in Common Fixture Traps

It is obvious that this waste seal must be maintained at all times. This can only be accomplished if at certain points vents be connected to the piping system in order to equalize the air pressure in the drains which threatens to be disturbed by the flow of wastes or by back pressure in the system. It is therefore also important that the horizontal drains and the stacks of the drainage system in

the building are so designed that they never flow full nor are under pressure.

Flow in Stacks

The main source of pneumatic disturbances are the stacks if not properly vented. Because the water is relatively high in the stacks, and since they do not flow full, the wastes carry along a considerable quantity of air downward. The water does not flow down in "slugs" separated by "pockets" of air. Experiments clearly show that it flows down the wall of the stack in a surprisingly uniform manner, forming a "sheet" around the inside circumference of the stack. The cross-section would be a ring of water of reasonably uniform thickness with a core of air which in certain sections of the stack may be traveling down with the water at almost equal velocity. This air movement will destroy the trap in the toilet bowl unless the stack be vented above the inlet of the horizontal drain. (see Fig. 10.)

Experiments have shown that, for any given size of stack and rate of discharge, the maximum velocity is attained after a certain distance of fall. In plumbing installations this distance varies 10 to 15 feet for smaller and 15 to 20 feet for larger pipes and is never greater no matter how high the stack. To avoid pneumatic disturbances, the stack should not flow over 1/4 full at the point of greatest velocity.

When entering the stack from the horizontal drain, the water will have the least velocity and consequently at this point of entrance the pipe will be the most filled. If it become filled up too much, water will start to back up in the stacks thus retarding the flow from the horizontal drains connected at that level and to create pneumatic effects (blowing out of seals) and considerable noise. Therefore, the allowable rate of flow into the stack at any floor should be only a fraction (1/2 to 1/3) of the maximum carrying capacity of the stack. These facts explain the necessity for the use of stacks of ample size.

Fig. 9 gives the pressures measured for various flows in a 28 feet high 3" stack connected at the bottom with a 4" drain 30 feet long. It is shown that for the flow of 90 g. p. m. obtained by the flushing of one toilet, a negative pressure is created of 15 inches of water 5 feet below the entrance, and a pressure of +10 inches at the bottom of the stack. For double this flow these pressures become respectively -28 inches and +32 inches; but the pressure remains atmospheric at the same depth of about 14 feet below the entrance. However, if the house drain receiving this flow were filled with water, pressures at the bottom of the stack rise to extremely high values, +45 inches having been measured for a flow of only 45 g. p. m. in the stack.

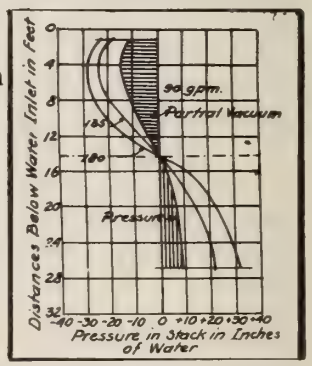

Distances Below Water Inlet in Feet
90 g.p.m.
Partial Vacuum
Pressure
-40 -30 -20 -10 0 +10 +20 +30 +40
Pressure in Stack in Inches of Water

Fig. 9. Variation in Air Pressure in a 3-in. Stack 28 ft. high

Flow in Horizontal Drains

Whenever water enters an approximately horizontal drain at a high velocity its momentum causes it to flow on in the drain at a much higher velocity than the slope of the drains (usually 1/4" to the foot) would cause (2 1/2 ft. per second in a 4" drain) and it will slow down only very gradually. For this reason a smooth flow at these high velocities (15 to 20 feet per second) can be obtained only in drains which are straight and without obstructions. Any bend sharper than 22 1/2^{0} will cause a spiral type of flow and thereby reduce the velocity. Such an obstruction is a house trap or running trap (see Fig. 10) which should only be installed for special conditions. The sudden decrease in velocity causes the water to rise in the drain vent thereby shutting off the air at A which consequently will be under great pressure. Fixtures connected in the region of A or at the lower level of the stack should, in case of a house trap, be vented with large short vents of great capacity to carry off a great quantity of air which normally should have passed down the sewer to the street. It has been shown above that all horizontal drains connected to the stack will, under normal flow, be either under a great enough pressure or a partial vacuum at the various floor levels to remove entirely the 2" water seal in the P trap connected to the fixtures. It is therefore imperative that each of these fixtures should be vented between the trap and the stack with a vent of sufficient size - not less than that of the trap (minimum 1 1/4", with a minimum of 2" for water closets). A few

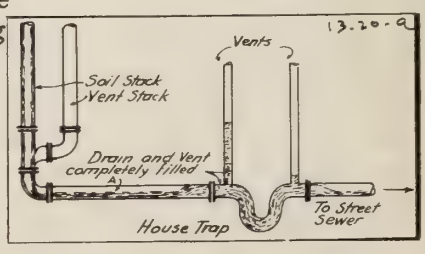


Fig. 10. Conditions in House Drain with Running Trap

fixtures, placed close together, may in some instances be protected by the same vent as will be explained later.

The dip of the fixture traps for other than water closets should never be above the point of venting to avoid self-siphonage (a condition in which the trap is drained along with the waste until the air passes the trap). Water closets may be placed up to 3 feet above the point of venting, since the danger of self-siphonage is much less.

Vents

A fundamental for proper venting is that the size and length of the vents be not only dependent on the number and kind of fixtures they serve, but also on the size of stack to which they are connected. For the same rate of flow-down, a greater volume of air-relief (against vacuum or pressure) is required in a 5" stack than in a 4" stack. For the same size (diameter) vent, the vent on a 5" stack should be shorter than that on a 4" stack.

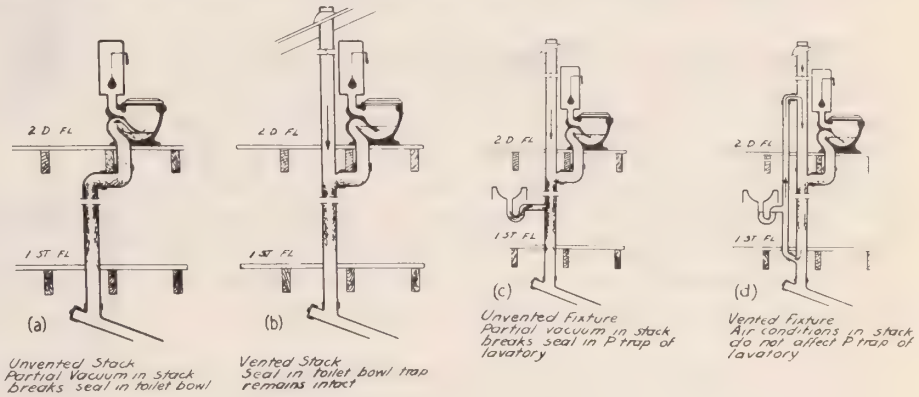


Fig. 11. Function of Vents

An important factor is that a minimum of pressure differential of only 1" of water is allowed in the vent, since most traps have water seals of 2 inches.

Vents should never be connected to stacks at such points where the entrance of liquid into the vents is possible (Fig. 12). Stack venting of fixtures is only applicable to fixtures on the top floor if grouped around the stack within a distance of 5 feet. (See Fig. 13,

Finally, it should well be realized that the air relief through a vent is not at all instantaneous but takes a certain amount of time (a few seconds at least) and that the maximum possible airflow in a stack is only a few times as large as the flow of water in the stack. For instance, for the maximum recommended rate of 180 g.p.m. in a 4" stack, the maximum possible airflow is 600 g.p.m.

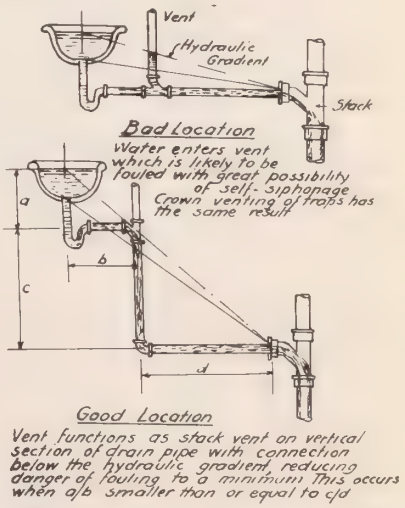

Vent
Hydraulic Gradient
Stack
Bad Location
Water enters vent which is likely to be fouled with great possibility of self-siphonage
Crown venting of traps has the same result
a
b
c
d
Good Location
Vent functions as stack vent on vertical section of drain pipe with connection below the hydraulic gradient, reducing danger of fouling to a minimum. This occurs when a/b smaller than or equal to c/d

Fig. 12. Location of Fixture Vents

The foregoing fundamentals of hydraulics must be understood in order to clearly comprehend the safeness or hazardness of plumbing fixtures, devices, tanks or other equipment.

A factor which probably does not often apply in a plumbing system, but which may be a hazard under certain conditions is one based on suction. If suction be applied to a pipe whose opening is near to the surface of a liquid, the liquid may be drawn into the pipe. If the distance of the pipe opening above the water remains the same, the danger increases as the diameter of the pipe increases. Open end pipes should therefore be an inch or more above the level of a liquid surface.

If the pressure in the water line becomes less than atmospheric pressure and if the water inlet be below or too close to the spill line, the waste water in the lavatory will be sucked into the water line. The water inlet should be at least one inch above the spill line. (Fig. 17). This is an example of back siphonage.

In large buildings or industries where large quantities of water are used, the flow through the water line may be so great that partial vacuum may be produced in any cross connection or interconnection, resulting in the suction of waste water or sewage into the water line (Fig. 17).

Fundamentals to be Observed in the Design of Tanks, Receptacles, Equipment and Plumbing Fixtures.

1. Every plumbing fixture and its connections with the water-supply distribution system and the plumbing drainage system should be such that contamination cannot flow, be forced, drawn or otherwise introduced into the water-supply distribution system.

2. The water-supply pipe should be brought separately to the fixture so that under no condition will any portion of the supply pipe be in contact with the waste in the fixture or waste coming from the fixture. No portion of the fixture should be used to convey water to the inlet end of a fitting, faucet or other inlet through which water is supplied to the fixture unless the waterway be sufficiently high to prevent back-siphonage of waste into the water-supply distribution system.

3. All water-supply outlets should terminate at a point above the spill line at a distance which is great enough to prevent the possibility of back-siphonage of waste into the water-distribution system.

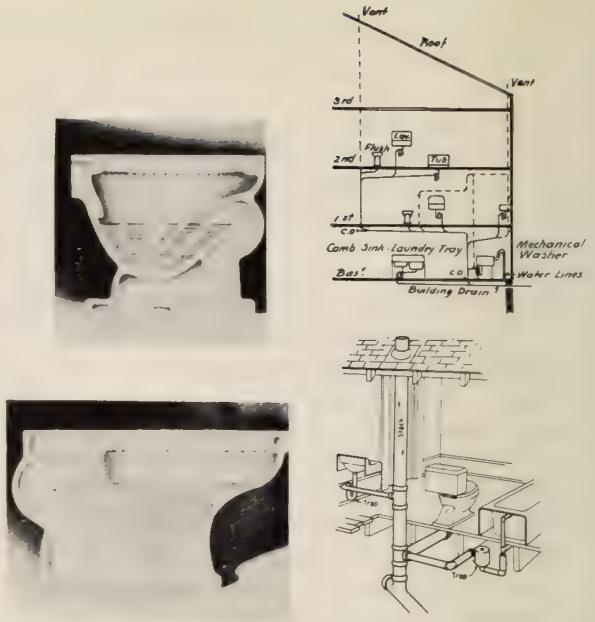


Fig. 13. Dwelling House Plumbing

Top Left : Ordinary Wash Down Toilet Bowl
Lower Left : Siphon Jet Toilet Bowl
Upper Right : Plumbing Diagram of Drains and Vents
Lower Right : Bathroom group arrangement for top floor, where stack venting is allowed if fixtures are 5 feet or less from stack

4. In addition to the water supply, there are certain fixtures and equipment such as dishwashing machines, soda fountains, sterilizers, food storage boxes, autoclaves, etc., which should be protected from contamination that may come through the drain or waste connection to the sewer. The waste pipe should not contact directly to the sewer, but should terminate above the spill line of the receptacle into which it discharges. Certain other fixtures such as instrument sterilizers, etc., should have independent drain, or waste pipes, and/or adequate vacuum breaker (Fig. 18) on the water supply.

5. When a safe water supply is being distributed to an institution, industry, etc., where hazards exist that may endanger the supply, the system should be protected from contamination by carrying the water service pipe to a receiving reservoir which is properly constructed and is above grade. The water service pipe should terminate at least six inches above the spill line of the receiving reservoir. Because of such potential hazards as flooding with sewage or with water that may contain dangerous wastes, the piping and outlets, cisterns, storage tanks and control tanks used in connection with drinking water supplies should be located as little as possible in basements, tunnels, or other space below ground level.

6. Care should be taken in relation to plumbing installations such as locating sewer and drain lines over the freezing compartments of ice machines, over water tanks, meat blocks, food containers, utensils that are used in the preparation and the serving of food, etc.

Methods and Devices for Prevention of Backflow and Back Siphonage

Surge Tanks: If an air gap separation be provided at each fixture, complete protection will be provided within the building as well as to the municipal supply. The separation may also be made at one point where the water service enters the building. However, this protects only the municipal water supply system. Where the air gap separation is made at the building water service entrance, a single surge tank is often used. The surge tank, which is illustrated in figure 14 consists of a reservoir and pump combination with the potable water supply delivered to the reservoir through an air gap. The surge tank is used often in installations where water is needed in industrial processes. The potable water piping system supplies the lavatory fixtures and drinking fountains while the pumped system may provide water for industrial processes. Dual systems are always hazardous, but when used, should be under strictest surveillance. Many dual piping systems are not adequately identified by a color code. A color code system is recommended to help prevent the possibility of the two systems becoming inadvertently interconnected.

When color marking is used, a green color should be used for potable waterlines and a yellow color for nonpotable waterlines. As painting long stretches of pipe may be costly and difficult, color bands, 3 inches wide may be applied at intervals which should not exceed 25 feet. The pipes should also be banded on both sides of points where they pass through walls or ceilings.

The surge tank may be used to serve single fixtures or equipment units, or entire house systems. The size of each unit is determined by the water demand rate which it is to accommodate. The rate of flow into the receiving reservoir of the surge tank is governed by the float valve. The booster pump draws suction from the reservoir, or surge tank, and discharges directly to the distribution system under pressure. When the discharge of the booster pump is to serve points where water will be withdrawn for domestic use the surge tanks should be properly covered to prevent contamination.

Vacuum Breakers. Two types of vacuum breakers have been developed. One is designed to be installed on the pressurized distribution system. This device is called a pressure type vacuum breaker, as it is designed to be operable even after having remained under hydrostatic pressure for extended periods of time. The other is called the non-pressure-type vacuum breaker. The non-pressure type vacuum breaker must always be installed on the atmospheric side of the fixture valve. The installation of a vacuum breaker on the atmospheric side of the last control valve is always preferred over the use of a pressure type vacuum breaker. This vacuum breaker is not designed to provide protection

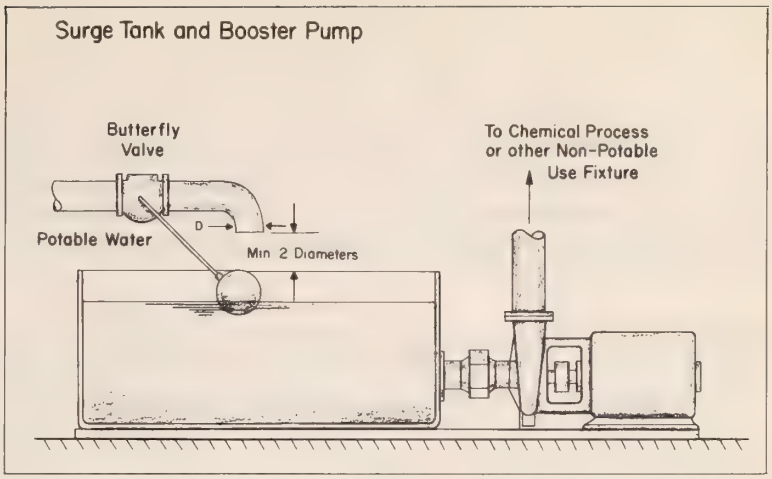


Fig. 14. Air Gap Principle

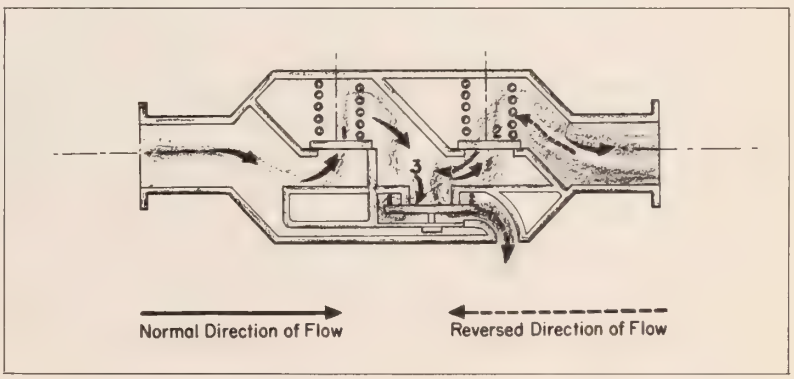


Fig. 15. Reduced Pressure Zone Backflow Preventer (Principle of Operation)

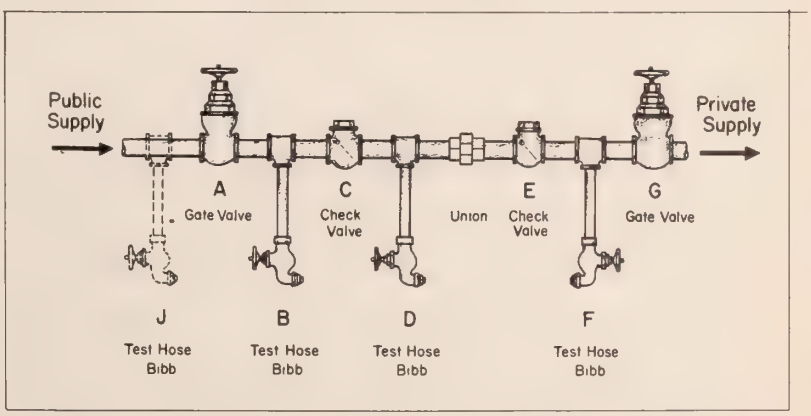


Fig. 16. Double Check-Double Gate Valves

against backflow resulting from backpressure and should not be installed where backpressure may occur.

The pressure type vacuum breaker is similar in operation to the non-pressure type, except that the valve which admits atmospheric pressure is spring loaded to assure positive opening of the valve even after having remained closed under hydrostatic pressure for extended intervals of time. It is designed for installation on the supply line ahead of the fixture valve, but should only be used if a non-pressure-type valve cannot be installed. This device does not provide protection against backflow resulting from backpressure, and it should not be installed where backpressure may occur.

Reduced Pressure Principle Backflow Preventer. The pressure and non-pressure type vacuum breakers are designed to prevent backsiphonage only and cannot be installed where backpressures are likely to occur. In situations where it would be extremely difficult to provide a physical break between two systems and where backpressures can be expected, a reduced pressure principle, backflow preventer can be used. This device consists of two, hydraulically or mechanically loaded, pressure reducing, check valves with a pressure regulated relief valve located between the two check valves as shown by figure 15.

Flow from the left enters the central chamber against the pressure exerted by the loaded check valve number 1. The supply pressure is reduced thereupon by a predetermined amount. The pressure in the central chamber is maintained lower than the incoming supply pressure through the operation of the relief valve number 3, which discharges to the atmosphere whenever the central chamber pressure approaches within a few pounds of the inlet pressure. Check valve number 2 is lightly loaded to open with a pressure drop of 1 psi (pound per square inch) in the direction of flow and is independent of the pressure required to open the relief valve. In the event that the pressure increases downstream from the device, tending to reverse the direction of flow, check valve number 2 closes, preventing backflow. Because all valves may leak as a result of wear or obstruction, the protection provided by the check valves is not considered sufficient. If some obstruction prevents check valve number 2 from closing tightly, the leakage back into the central chamber would increase the pressure in this zone, the relief valve would open, and flow would be discharged to the atmosphere.

When the supply pressure drops to the minimum differential required to operate the relief valve, the pressure in the central chamber should be atmospheric. If the inlet pressure should become less than atmospheric pressure, relief valve number 3 should remain fully open to the atmosphere to discharge any water which may be caused to backflow as a result of backpressure and leakage of check valve number 2.

Malfunctioning of one or both of the check valves or relief valve should always be indicated by a discharge of water from the relief port. This factor is an important advantage over earlier backflow devices. The pressure loss through the device may be expected to average between 10 and 20 pounds per square inch within the normal range of operation, depending upon the size and flow rate of the device.

Double Check-Double Gate Valves

The double check-double gate valve assembly, shown in Figure 16 is a very useful and, when properly maintained, reliable means of backflow protection for intermediate degrees of hazard. Frequently referred to as the Factory-Mutual assembly, this device had been in service at some plants since the early 1900's. As in the case of other backflow preventers, the double check-double gate valve assembly should be inspected at regular intervals.

The double check-double gate system has the advantage of a low head loss. With the gate valves wide open the two checks, when in open position, offer little resistance to flow.

Double check-double gate assemblies should be well designed and constructed. The valves should be of all bronze construction with removable rubber facings. Test cocks should be provided.

Other Methods. Other methods and devices have been promoted for the separation of auxiliary systems or for the prevention of backflow. Among these are the single check valve, the plain double check valve assembly, the swivel connection, and the barometric loop. The first 3 types are not recommended.

The barometric loop consists of a vertical loop of pipe extending at least 35 feet above the highest fixture. The principle is that a complete vacuum cannot raise water to an elevation greater than 33.9 feet. The device, however, does not provide protection against backflow due to backpressure and the installation of a pipe loop of this height is usually difficult and expensive. As a result it is not widely used.

Cross connections where protective devices are required and critical level (C-L) settings for backflow preventers*

Fixture or equipment	Method of installation
Aspirators and ejectors	C-L at least 6 inches above flood level of receptacle.
Dental units	On models without built-in vacuum breakers--C-L at least 6" above flood level rim of bowl.
Dishwashing machines	C-L at least 6" above flood level of machine. Install on both hot and cold water supply lines.
Flushometers (Closet and Urinal)	C-L at least 6" above top of fixture supplied.
Garbage can cleaning machine	C-L at least 6" above flood level of machine. Install on both hot and cold water supply lines.
Hose outlets	C-L at least 6" above highest point on hose line.
Laundry machines	C-L at least 6" above flood level of machine. Install on both hot and cold water supply lines.
Lawn sprinklers	C-L at least 12" above highest sprinkler or discharge outlet.
Steam tables	C-L at least 6" above flood level.
Tank and vats	C-L at least 6" above flood level rim or line.
Trough urinals	C-L at least 30" above perforated flush pipe.
Flush tanks	Equip with approved ball cock. Where ball cocks touch tank water, equip with vacuum breaker at least 1" above overflow outlets. Where ball cock does not touch tank water, install ball cock outlet at least 1" above overflow outlet or provide vacuum breaker as specified above.
Hose bibs (where aspirators or ejectors could be connected).	C-L at least 6" above flood level of receptable served.

* Critical level (C-L) is defined as the level to which the backflow preventer (vacuum breaker) may be submerged before backflow will occur. Where the C-L is not shown on the preventer, the bottom of the device shall be taken as the C-L.

Plumbing Fixtures and Improper Design Commonly Responsible for Plumbing Hazards.

1. Flush Valve - Satisfactory mechanical operation of most flush valves depends upon the maintenance of a continuous positive pressure in the water supplies. Should a vacuum occur in the supply line, the flush valve may open and back-siphon the fixture contents through the siphon-jet opening. A vacuum breaker of approved design (Fig. 18) should therefore be installed between the valve and the fixture, as it should not be subjected to water pressure.

2. Flush Tank - To insure quietness of operation the inlets to flush tanks are almost always submerged. If the ball cock leaks or if it be opened for the purpose of filling the tank during a period of vacuum in the supply line, a portion of the tank contents may be back-siphoned carrying with it any pollution which may be in the tank.

There are three types of Flush Tanks in general use for toilets:

a. The tank built integral with the toilet bowl.

b. The low, tank, separate from the bowl, the outlet of which is usually two or more inches

above the top of the bowl.

c. The high tank most often used with a wash-down bowl.

With the integral tank there is so little difference in elevation of water in the tank and bowl that only partial stoppage in the latter will permit a mixture of the bowl and tank water. Such fixtures should therefore be considered deficient unless the tank-water inlets be adequately protected against back-siphonage.

Low tanks are also subject to pollution by a mixture of the bowl contents with the tank water. For this reason they should be provided with a back-flow preventer which prevents an eventual vacuum in the hush pipe.

The possibilities of back-siphonage from a high tank to supply lines are very slight. High tanks are usually open and consequently are subject to air pollution but other possibilities of contamination exist, such as by vermin or leakage from pipes passing above the uncovered tanks.

3. Lavatories, Bath Tubs, and Laundry Trays - A large percentage of these are supplied through submerged inlets. Although overflow outlets may be some distance below the rim, they cannot be depended upon. Conditions may obtain where back-siphonage may occur. Corrections should be made eliminating the submerged inlets.

4. Soda Fountains, Sinks, Bidets, Aspirators, and Dental Cuspidors - These present more hazards than most of the fixtures with submerged inlets. The inlets to soda fountain sinks and bidets are most commonly located at the bottom of the fixtures and are continuously submerged. Aspirators are suction pumps operating on the injector principle (Fig. 13, Chapter X) which consists of the creation of a partial vacuum at the point where the pipe diameter is considerably decreased. Protection against back-siphonage must be provided.

5. Industrial Equipment - The most common of these appliances are laundry and dishwashing machines. In almost all of these installations, the inlets are either submerged or become submerged when the machine is in operation. Back-siphonage is the hazard, and proper air breaks should be provided.

6. Hospital Fixtures - Bedpan washers and sterilizers may have a portion of their contents drawn into the water-supply line when a vacuum exists in the latter. Back-siphonage may occur in sterilizers during the cooling period and condensation of steam. A partial vacuum is created in the sterilizer and if it be connected to the drainage system may back-siphon water from the drainage line. Again air breaks are indicated.

7. Drinking Fountain - There are only a few fixtures in which contamination and disease may be spread without occurrence of a vacuum. Foremost of these is the drinking fountain. A joint report of the committee on plumbing of the American Public Health Association and the conference of state sanitary engineers outlined the essential factors necessary for the construction of a safe, sanitary drinking fountain which are as follows:

a. The fountain should be constructed of impervious material, such as vitreous china, porcelain, enameled cast iron, other metals, or stoneware.

b. The jet of the fountain should issue from a nozzle of non-oxidizing, impervious material set at an angle from the verticle such as to prevent the return of water in the jet to the orifice or orifices from which the jet issues. The nozzle and every other opening in the water pipe or conductor leading to the nozzle should be above the edge of the bowl so that nozzle or opening will not be flooded in case a drain from the bowl of the fountain becomes clogged.

c. The end of the nozzle should be protected by nonoxidizing guards to prevent the mouth and nose of persons using the fountain from coming into contact with the nozzle. Guards should be so designed that the possibility of transmission of infection by touching the guards is reduced to a minimum.

d. The inclined jet of water issuing from the nozzle should not touch the guard, and thereby cause spattering.

e. The bowl of the fountain should be so designed and proportioned as to be free from corners which would be difficult to clean or which would collect dirt.

f. The bowl should be so proportioned as to prevent unnecessary splashing at a point where

HOW TO PREVENT DISEASE BY REMOVING BACKSIPHONAGE HAZARDS IN PLUMBING

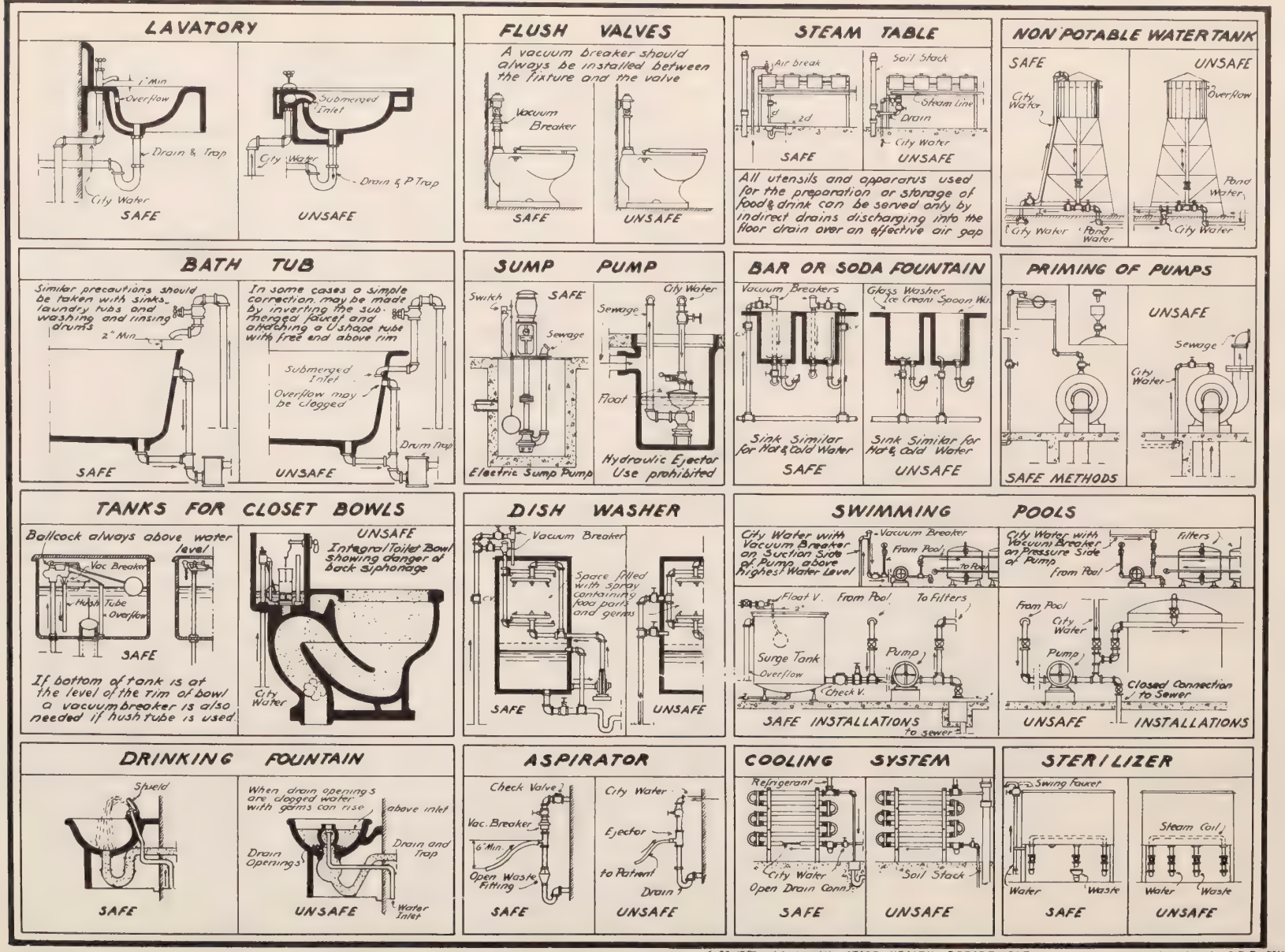


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Fig. 17

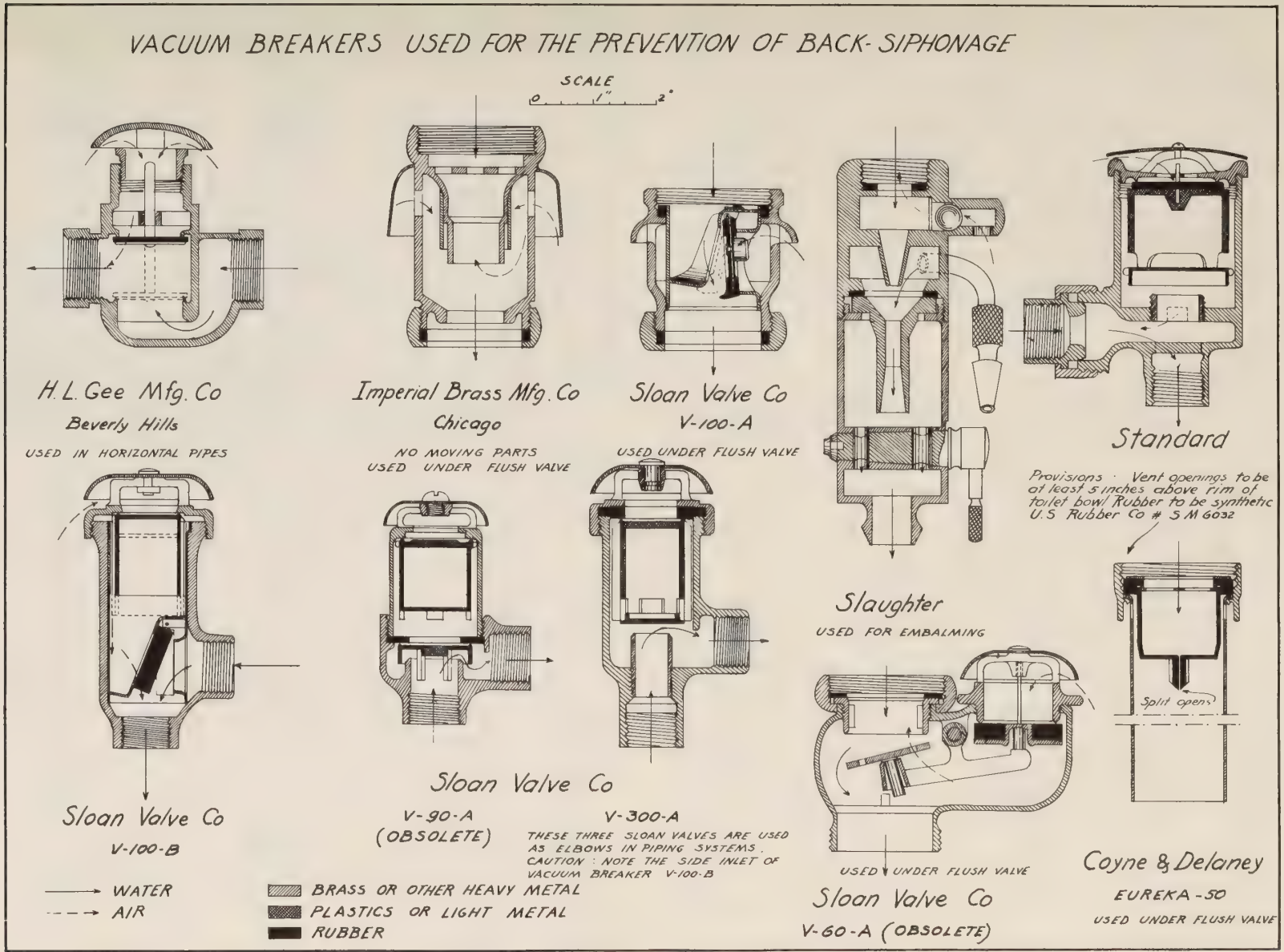
VACUUM BREAKERS USED FOR THE PREVENTION OF BACK-SIPHONAGE
SCALE
0 1" 2"
H.L. Gee Mfg. Co
Beverly Hills
USED IN HORIZONTAL PIPES
Imperial Brass Mfg. Co
Chicago
NO MOVING PARTS
USED UNDER FLUSH VALVE
Sloan Valve Co
V-100-A
USED UNDER FLUSH VALVE
Standard
Provisions · Vent openings to be at least 5 inches above rim of toilet bowl Rubber to be synthetic U.S. Rubber Co # S M 6032
Slaughter
USED FOR EMBALMING
Split open
Sloan Valve Co
V-100-B
Sloan Valve Co
V-90-A
(OBSOLETE)
V-300-A
THESE THREE SLOAN VALVES ARE USED AS ELBOWS IN PIPING SYSTEMS. CAUTION: NOTE THE SIDE INLET OF VACUUM BREAKER V-100-B
USED UNDER FLUSH VALVE
Sloan Valve Co
V-60-A (OBSOLETE)
Coyne & Delaney
EUREKA-50
USED UNDER FLUSH VALVE
WATER
AIR
BRASS OR OTHER HEAVY METAL
PLASTICS OR LIGHT METAL
RUBBER
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Fig. 18

the jet falls into the bowl.

g. The drain from the fountain should not have a direct physical connection with a waste pipe, unless the drain be trapped.

h. The water supply pipe should be provided with an adjustable valve fitted with a loose key or an automatic valve permitting the regulation of the rate of flow of water to the fountain so that the valve manipulated by the users of the fountain will merely turn the water on or off.

i. The height of the fountain at the drinking level should be such as to be most convenient to persons utilizing the fountain. The provision of several steplike elevations to the floor at the fountain will permit children of various ages to utilize the fountain.

j. The waste opening and pipe should be of sufficient size to carry off the water promptly. The opening should be provided with a strainer.

8. Household Filters - These are used where there is a deterioration in the quality of the delivered water. Unless rigid control be maintained over the cleaning and sterilizing of the filters, their use should be discouraged.

9. Improper Placing of Soil and Waste Pipes - Another source of contamination is through the improper location of soil and waste pipes with respect to water storage tanks and food handling and ice manufacturing equipment. Leakage is the chief source of hazard.

10. Open Top Water Containers - The use of open-top water supply and storage tanks is conducive to the entrance of dust and vermin with a resultant contamination of the water supply.

Vacuums in Potable Water Supplies

It has been found that the most important criterion used to determine what is and what is not defective plumbing is that which allows back-siphonage. This criterion is so important because of the variability that occurs in the pressure in the potable water supply lines. It has been found that the pressure in these lines may be reduced to below atmospheric pressure from a few to many times a day. In 1936 the National Association of Master Plumbers established a research program at the Institute of Hydraulic Research at the State University of Iowa on the problem of back-siphonage and the resultant contamination of water supplies. The conclusions of this investigation are given below:

1. Vacuum formations in water pipes cannot all be explained by analogy with the action of a simple siphon. Negative pressures in complicated piping systems due to a loss of pressure by friction may be very common.

2. Contaminated water from a few submerged inlet fixtures in buildings contaminate the entire piping system in that building and the contamination may also get back into the street water mains.

3. Vacuums in pipe systems of buildings can be caused by negative water hammer pressure waves, local narrowing in pipes, and condensation of steam in hot-water tanks.

4. The two principal causes of drop of pressure below atmospheric are "shut off" of pressure due to excessive friction loss. Investigations reveal that at least 90% of all vacuum formations, and therefore 90% of the back-siphonage hazards, are caused by excessive pressure loss due to improper water piping design and workmanship.

5. A separate water supply to submerged inlet fixtures in a building cannot be considered as a practical and adequate elimination of water contamination dangers because: First, the cross-connection hazard is enhanced due to the dual water supplies, one safe and the other unsafe; second, it cannot be used for submerged inlet fixtures requiring a pure water supply and also for various hot-water fixtures.

6. Installation of air inlets at tops of water risers and at various other points for purposes of vacuum prevention in water pipes is not the proper solution to the back-siphonage problem because: First, from a pneumatic standpoint entire prevention of partial vacuum formation by this means is practically impossible as a local narrowing may cause vacuums of any degree; second, air inlet devices installed under constant water pressures are entirely undependable.

7. The correct and only solution to the back-siphonage problem is elimination and correction of the individual unsafe fixture. The unsafe fixture is the fundamental evil in the plumbing system that makes back-siphonage possible, and therefore should be the point of attack.

8. Inlets should be raised above the top of the fixture a distance equal to the value from one of the two formulae, G = 2D or G = 2 1/4 times the square root of A, where G is the gap in inches between the inlet and the highest possible water level of the fixture, D the diameter of water inlet, and A is the minimum area of the inlet. This will prevent any siphonage from such a fixture and will provide a substantial factor of safety. For common types of fixtures, the following heights of gaps are recommended: Lavatory, 1 inch; kitchen sink and laundry trays, 1 1/2 inches; bathtub, 2 inches.

9. Under certain conditions, as specified in this report, overflows leading from the fixture to the atmosphere may be considered as determining the maximum possible water level of a fixture, and the water-supply inlet need only be raised above the overflow. However, raising inlets above overflows which connect to the atmosphere, either directly or through an air gap in the overflow pipe, cannot be considered as an ideal solution by any means.

10. The vacuum-breaking principle as defined herein has the necessary requisites for a proper solution to the back-siphonage problem. The proper application of this principle entails rigid requirements relating to the vacuum-breaking device used.

11. It is recommended that the vacuum-breaking principle be accepted as a tentative standard for the proper solution to the back-siphonage problem if the vacuum breakers used meet all requirements specified in this report. It is further suggested that such vacuum-breaking devices, installed on actual installations, be carefully observed for a number of years to note their performance characteristics before they are definitely accepted as standard.

12. The tank closet with the constantly submerged inlet presents as great a back-siphonage hazard as any fixture in the plumbing system. Every effort should be made by manufacturers of closet tanks to have the entire float valve and water-supply piping connections installed above the overflow level of the tank if the tank water be subject to sewage pollution. Unless especially well designed, it is not recommended that moving part vacuum-breaking devices be used in closet tanks because of the corrosive conditions.

13. Automatic flush valve fixtures should be protected from back-siphonage by incorporation of the following items: (a) A loose check valve to be incorporated in the stop valve; (b) Stable unit piston to be used if piston type valve be installed; (c) Vacuum breaker between the control valve and fixture which meets specified requirements for vacuum breakers; (d) No water supply connection to a closet bowl below the flush rim of the bowl should be permitted.

14. The frostproof closet presents such pronounced water-pollution hazards that its use even under the best conditions cannot be considered as satisfactory.

15. A great many hospital fixtures are excellent examples of the water pollution hazards that can be introduced in the design of various special fixtures when important sanitary consideration is overlooked.

16. Manufacturers of special water-supply and plumbing equipment and fixtures should be ever alert regarding the introduction into the design of the fixture of back-siphonage problem; that is, "inlet above top of fixture."

17. The best program to inaugurate for the elimination of direct cross-connection with auxiliary private water supplies is the eliminating of the wholesale presence of such supplies in buildings served with the public water supply. Only when such auxiliary supplies are reduced to a minimum can regulations and inspections be entirely effective.

18. Direct connection of city water to cooling and condensing systems used in gas compressors, refrigerating apparatus, and air-conditioning equipment should be condemned. Re-use of such water in the domestic supply systems of buildings is not satisfactory from a sanitary viewpoint.

19. Submerged inlet water-supply connections to water used for air washing, cooling, humidifying, and dehumidifying should not be allowed.

20. In buildings, water that flows in a pipe of considerable length under gravity, should never be used again in the domestic supply system. The chances of the pipe being used for a waste connnection are too great.

21. Tests indicate that the vacuum causing flow of air through rim ports of closet bowls and urinals, or through or over other surfaces likely to have polluted liquid drops adhering to them, should not be over 1 inch of water in order to prevent the picking up of polluted liquid droplets and the carrying back of such pollution in the form of a spray into the water-supply pipes.

22. The installation of water-piping systems and all direct connections thereto, must be made by individuals possessing a peculiar knowledge of the flow of fluids, and of the action of siphonage, and by individuals understanding the dangers of bacterial infection, and by individuals duly licensed under the plumbing law.

Corrective and Preventive Measures for Hospitals, Cafeterias, Launderies, Dormitories, and Hotels.

Lavatory faucets should be provided with a satisfactory gap between the lip of the faucet and the rim of the lavatory.

Bathtubs should be provided with similar gap between the faucet and the rim of the tub.

Closets should be the tank type and the filling tube should have a backflow preventer located at least one inch above the water line in the tank; that is, above the overflow point. Flushometer plus vacuum breaker is allowable.

Steam tables should be fed with water by means of an over-the-rim-faucet. The drain for these should empty into an open pot trap.

Sinks should be provided with over-the-rim feed.

Dishwashers should be supplied with water by means of a faucet that is higher than the overflow point by a safe margin.

There should be a distinct break in the water line before supplying potato peelers.

Water fed to condensers should, upon leaving the condenser, be emptied into an open pot trap.

A sitz bath should be fed, preferably, from a faucet over-the-rim of the tub above the overflow point of the bath. (If this be not possible a device may be arranged whereby the water empties into a standpipe a foot or so above the bath.) This standpipe feeds the sitz bath below the rim and this same standpipe, being open at the top, provides a vent to eliminate all possibility of back-siphonage.

Continuous flow baths should be handled the same as sitz baths.

Bidets should be fed from an open hopper. This hopper should be of a height to provide the proper water pressure. The break in the continuity in this case would be between the water line and the hopper.

Instrument and utensil sterilizers should be supplied with water by means of a swinging over-the-rim faucet. In this case, the faucet must be swung out of place before the cover of the sterilizer can be lowered. The waste line from the sterilizers should empty into an open pot trap.

It is satisfactory to supply a water sterilizer direct but when the water leaves the sterilizer, it must be provided with a break in the continuity. The waste line should empty into an open pot trap before reaching the sewer.

All water suction devices or aspirators are a hazard and all new installations should provide suction by means of a vacuum pump. A vacuum pump and receiving tank should be located some

place in the building and each room piped to this vacuum tank. When the suction is used, a receiver is installed in the room which collects any foreign matter in order to keep the suction system clean. This, of course, is ideal, but proper use of a vacuum breaker is practicable.

All installations needing submerged inlets like bar, or soda fountain installations, scalding vats in slaughter houses, etc., should have the intake pipe looped above the maximum water level and there provided with an air break.

Table 1. Fixtures and their Water Supply Protection

Fixtures	Type of protection*	Remarks
Aspirators:		
Laboratory	Vacuum breaker	
Portable	Vacuum breaker	
Vacuum system	Vacuum breaker	
Bedpan:		
Washers	Vacuum breaker	
Washer hose	Vacuum breaker	Locate 5 feet above floor.
Boiling type sterilizer	Air gap	Not less than twice the effective opening of the water supply.
Exhaust condenser	Vacuum breaker	
Flush floor drain	Vacuum breaker	
Hose connection	Vacuum breaker	Locate 6 feet above floor.
Pressure instrument washer - sterilizer	Vacuum breaker	
Pressure sterilizer	Vacuum breaker	
Vacuum systems:		
Cleaning	Air gap or vacuum breaker	
Fluid suction	Air gap or vacuum breaker	

*Where vacuum breakers are used, they shall be installed after the last control valve.

Clinical, Hydrotherapeutic and Radiological Equipment: All clinical, hydrotherapeutic, radiological, or any equipment, whether mentioned or not, which is water supplied and/or discharges to the waste system, shall meet the requirements of the Code covering cross-connections, air gaps, vacuum breakers, and check valves.

Special equipment and devices found under these classes include:

Table 2

Clinical	Hydrotherapeutic	Radiological	Other
Dental Cuspidors	Control units	Diagnostic X-ray	Violet ray
Surgical Cuspidors	Arm bath	Therapy X-ray	Photographic developing
Dental (flush rim) lavatories	Leg bath	X-ray target	Film developing
	Foot bath	X-ray transformers	Microscopic
Colonic irrigation	Tub bath	X-ray oil tank	
Sitz bath	Immersion bath	Diffraction	
Emergency bath	Shower bath	X-ray developing	
Receiving bath	Needle bath		
Prenatal bath	Tank		
Infant bath	Pool		
Prophylaxis	Hose		
Shampoo	Syringe		
Massage	Douche		

Plumbing Code and Code Specifications

A plumbing Code is a system of principles and rules pertaining to the sanitary installations of a water supply and drainage system in a building, together with the number and kind of fixtures needed for satisfactory service. It prescribes the material, quantity, and form of piping and

fixtures; it also defines the size of water pipes and drains for the needed number of fixtures; and similar matter to ensure a sanitary and satisfactory installation.

A completely satisfactory plumbing code which is agreeable to most plumbing authorities in this country is difficult to develop. The specifications and tables given here are based on the specifications of the American Standards Association's National Plumbing Code, ASA, A 40.8 - 1955, sponsored by the American Public Health Association and the American Society of Mechanical Engineers with participation of the most pertinent national associations, and the Proposed Revision of the latter Code of September 1962 by the Technical Committee on Plumbing Standards of the U.S. Public Health Service. The latter also proposes a Plumbing Ordinance which is given at the end of this chapter.

Plumbing Codes usually specify:

a. That it is unlawful for any person to act as a plumber, be it as Master Plumber or Journeyman Plumber, unless so licensed after passing an examination and, (for Master Plumbers) making a security bond.

b. That all plumbing must be executed in accordance with plans previously deposited with and approved by the Plumbing Inspector in writing.

c. That no part of the work should be covered or concealed until after inspection by the Plumbing Inspector.

d. Describes the duties of the Plumbing Inspector, and the fees for permits and inspections.

e. Describes the method of tests of the plumbing by the Plumber in presence of the Inspector.

f. Specifies that extensions or alterations of existing piping systems, except minor repairs, must be handled as work in a new building by duly licensed persons.

g. Describes the procedure for the connection of new plumbing to existing public sewers.

h. Gives full police power to the administrative authority and the Plumbing Inspector to enter any building for inspection purposes.

Such plumbing codes should also provide for periodic inspections of plumbing to eliminate, as far as possible, the cross connection hazards. Very desirable is, likewise, a provision for the establishing of educational facilities for technicians.

The State Sanitary Codes, in addition, usually provide that plans for all new public installations, or important changes of old public installations, should be submitted to the Health authority for approval.

Specifications for Pipes and Connections

Water Supply - The water-service pipes of any building should be of sufficient size to permit a continuous ample flow of water at any time. The flush pipe for water closets should not be less than 2 inches in diameter for the low tank and 1 1/2 inches for high tank combinations and the water from flush tanks should be used for no other purpose.

Table 3. Minimum sizes of fixture water supply lines

Type of fixture or device	Nominal pipe size (inches)	Type of fixture or device	Nominal pipe size (inches)
Bathtubs	1/2	Shower (single head)	1/2
Combination sink and tray	1/2	Sinks (service, slop)	1/2
Drinking fountains	3/8	Sill cocks	3/4
Dishwashing (domestic)	1/2	Sinks flushing rim	3/4
From curb to dwelling	3/4*	Urinal (flush tank)	1/2
Hose bibs	1/2	Urinal (direct flush valve)	3/4
Hot water boilers	3/4	Water closet (tank type)	3/8
Kitchen sink, residential	1/2	Water closet (flush valve type)	1
Kitchen sink, commercial	3/4	Washing machine, residential	1/2
Laboratory	3/8	Wall hydrant	1/2
Laundry trays, 1, 2, 3, compartments	1/2		

* Note: The size of pipe depends on the "demand load" of the fixtures inside the building expressed in fixture units (See Table 7).

Table 4 Fixture Units Per Fixture or Group

Fixture Type	Fixture-Unit Value as Load Factors	Minimum Size of Trap[2] Inches	
Bathtub[1] (with or without overhead shower)	2		1½
Bidet	3		1½
Combination sink and laundry tray	3		1½
Combination sink and laundry tray with food-disposal unit	4	separate traps	1½
Dental unit or cupsidor	1		1¼
Dental lavatory	1		1¼
Drinking fountain	½		1
Dishwasher, commercial			2
Dishwasher[2] domestic	2		1½
Floor drains[3]	1		2
Kitchen sink, domestic	2		1½
Kitchen sink, domestic with food waste grinder	3		1½
Lavatory[4]	1	Small P.O.	1¼
Lavatory[4]	2	Large P.O.	1½
Lavatory, barber, beauty parlor	2		1½
Lavatory, surgeon's	2		1½
Laundry tray (1 or 2 compartments)	2		1½
Shower stall, domestic	2		1½
Showers (group) per head[2]	3		
Sinks			
Surgeon's	3		1½
Flushing rim (with valve)	8		3
Service (Trap standard)	3		3
Service (P trap)	2		2
Pot, scullery, etc.[2] commercial	4		2
Commercial, with food grinder unit			2
Urinal, pedestal, syphon jet, blowout	8	Nominal	3
Urinal, wall lip	4		1½
Urinal stall, washout	4		2
Urinal trough[2] (each 2-ft. section)	2		1½
Wash sink[2] (circular or multiple) each set of faucets	2	Nominal	1½
Water closet, tank-operated	4	Nominal	3
Water closet, valve-operated	8		3

1. A shower head over a bathtub does not increase the fixture value.
2. See Table 5 for method of computing unit value of fixtures not listed in this Table or for rating of devices with intermittent flows.
3. Size of floor drain shall be determined by the area of surface water to be drained.
4. Lavatories with 1¼ or 1½ inch trap have the same load value; larger P.O. plugs have greater flow rate.

Table 5 Fixtures not listed in Table 4 shall be estimated in accordance with Table 5

Fixture drain or trap size	Fixture-unit value
1 1/4 inches and smaller	1
1 1/2 inches	2
2 inches	3
2 1/2 inches	4
3 inches	5
4 inches	6

For a continuous or semicontinuous flow into a drainage system, such as from a pump, pump ejector, air-conditioning equipment, or similar device, two fixture units shall be allowed for each gallon-per-minute of flow.

A shower head over a bath tub adds no fixture units. The number of fixture units given above for lavatory, kitchen sink, bath tub, water closet, laundry tray, shower bath and floor drains are doubled if the fixtures be in public use. The trap size and fixture drains remain the same except as indicated.

Plastic Pipe

At the request of State Sanitary Engineers and the Conference of Municipal Public Health Engineers, the National Sanitation Foundation agreed to establish facilities to perform physical testing of plastic pipe against recognized physical standards. The American Water Works Association had not established such standards; therefore, it was agreed that the Commercial Standards of the U. S. Department of Commerce should be used. The performance specifications of the Commercial Standards are based, insofar as possible, on a simulated 50 year life.

The National Sanitation Foundation insignia on plastic pipe of all types signifies that the pipe is safe for potable water use, and that it conforms with the physical specifications of the applicable Commercial Standard for the material concerned, or in those instances where there is no Standard, the pipe is tested against working stresses.

House Sewer and House Drain

The house sewer is made of extra heavy cast iron or vitrified clay pipe, concrete pipe, or bituminized fiber pipe. The required size of the house sewer will vary according to the number of fixtures drained by it. The house drain is of cast-iron pipe of a size, depending, like the house sewer, on number of fixtures drained by it.

Pipe Cleanouts

A clean-out, easily accessible, must be provided at or near the foot of each vertical waste or soil pipe. There must also be a clean-out near the junction of the building drains and building sewer, or a clean-out with a "Y" branch inside the building wall. In horizontal drain lines of 4" diameter or less they should not be more than 50 feet apart, and not more than 100 feet for larger pipe sizes. Furthermore they should be installed at each change of direction of the building drain greater than a 45° angle. They should be installed in such a way that clean-outs on 4" or larger pipes have a clearance of at least 18" for rodding.

Table 6 Building Drains and Sewers

Diameter of Pipe	Maximum Number of Fixture Units That May Be Connected to Any Portion[1] of the Building Drain or the Building Sewer			
	Fall per Foot			
Inches	1/16-Inch	1/8-Inch	1/4-Inch	1/2-Inch
2			21	26
2-1/2			24	31
3		36[2]	27[2]	36[2]
4		180	216	250
5		390	480	575
6		700	840	1,000
8	1,400	1,600	1,920	2,300
10	2,500	2,900	3,500	4,200
12	3,900	4,600	5,600	6,700
15	7,000	8,300	10,000	12,000

1. Includes branches of the building drain.
2. Not over two water closets.

Table 7 Horizontal Fixture Branches and Stacks

Diameter of Pipe	Maximum Number of Fixture Units That May Be Connected To:			
	Any Horizontal Fixture Branch[1]	One Stack of 3 Stories in Height or 3 Intervals	More Than 3 Stories in Height	
			Total for Stack	Total at One Story or Branch Interval
Inches				
1-1/4	1	2	2	1
1-1/2	3	4	8	2
2	6	10	24	6
2-1/2	12	20	42	9
3	20[2]	30[3]	60[3]	16[2]
4	160	240	500	90
5	360	540	1,100	200
6	620	960	1,900	350
8	1,400	2,200	3,600	600
10	2,500	3,800	5,600	1,000
12	3,900	6,000	8,400	1,500
15	7,000	.....	.....	.....

1. Does not include branches of the building drain.
2. Not over two water closets.
3. Not over six water closets.

Table 8 Capacity of Grease Interceptors

Total Flow Through Rating in GPM	4	6	7	9	10	12	14	15	18	20	25	35	50
Grease Retention Capacity in lbs.	8	12	14	18	20	24	28	30	36	40	50	70	100

Table 9 Maximum loads for any one branch interval on multistory soil and waste stacks*

Diameter of stack	Number of branch intervals													Load limit for stacks f.u.
	3 f.u.	4 f.u.	5 f.u.	6 f.u.	7 f.u.	8 f.u.	9 f.u.	10 f.u.	11 f.u.	12 f.u.	13 f.u.	14 f.u.	15 f.u.	
2 --------	3	----	----	----	----	----	----	----	----	----	----	----	----	10
2½ -------	8	7	----	----	----	----	----	----	----	----	----	----	----	28
3** ------	20	18	17	16	----	----	----	----	----	----	----	----	----	102
4 --------	100	90	84	80	77	75	73	72	71	70	69	68	68	530
5 --------	325	205	190	180	175	170	165	162	159	157	156	154	153	1,400
6 --------	385	350	325	310	300	290	285	280	275	271	268	266	263	2,900
8 --------	875	785	735	700	675	655	640	630	620	612	606	600	594	7,600
10 -------	1,560	1,405	1,310	1,250	1,205	1,170	1,140	1,125	1,110	1,095	1,080	1,075	1,062	15,000
12 -------	2,435	2,195	2,045	1,950	1,800	1,825	1,790	1,755	1,730	1,705	1,685	1,670	1,655	26,000
15 -------	4,375	3.935	3,675	3,500	3,380	3,280	3,210	3,150	3,110	3,060	3,030	3,000	2,975	50,000

* These limits are applicable only when the maximum load within any 1 branch interval is not greater than $N\left(\frac{1}{2n}+\frac{1}{4}\right)$, where N = permissible load on a stack of 1 or 2 branch intervals, and n = number of branch intervals on the stack under consideration.

** Not more than 2 water closets or bathroom groups within each branch interval nor more than 6 water closets or bathroom groups on the stack.

Interceptors

Interceptors are traps for the removal from the wastes of grease in excessive amounts, inflammable waste, sand and other harmful ingredients. They are never required for private living quarters or dwelling units.

Where required, they must be so installed as not to become air bound or permit siphonage, and be readily accessible for cleaning and inspection. Water jacketed or similar type interceptors, where the water supply is used for coagulating grease, are prohibited. Oil interceptors should have a minimum capacity of six cubic feet plus one cubic foot for each vehicle serviced over three, or one cubic foot for each 100 square feet of surface drained into the interceptor.

Fixtures

Fixtures should be of modern and approved types and material. Closets should be molded in one piece, should hold sufficient water between flushes so that surfaces should not be fouled, and should have a flushing rim that will insure complete cleansing of the inside of the bowl. All fixtures should be installed to allow ease of cleaning. Built in and encased plumbing should not be approved. The overflows from wash bowl, bathtubs, etc., should enter waste pipes on the inlet side of the trap. Good practice requires that all fixture pipes run directly into the wall and that no lead pipes or traps be within 12 inches of the floor unless protected. Strong metal strainers are required at the outlets of all fixtures except closets and pedestal urinals. All fixtures must be provided with water through an air gap as prescribed. Where such installations are not feasible, they must be provided with a back flow preventer.

Used plumbing fixtures may be installed when inspected and found to be in satisfactory physical and sanitary condition.

Indirect Waste Pipes

Indirect waste pipes are drains which discharge into and above the flood level of an open accessible slop sink or floor drain, properly trapped and vented, or through an air gap to the inlet side of the trap serving the fixture or apparatus. The air gap must be at least twice the effective opening of the special waste pipe.

Indirect waste pipes serve the following apparatus: refrigerator, ice box, steam table, or any other receptacle or device in which food or drink is stored, prepared, or processed; dishwashing machines (except those in private living quarters) unless the drain be immediately adjacent to and connected to a floor drain; a drain, overflow, or vent to the water supply system; all stills, sterilizers, and equipment requiring cooling water. Stacks serving individual waste pipes receiving the discharge from drinking fountains or refrigerators on three or more floors must, moreover, be independently vented to the outside air.

Special Waste Pipes

No toxic, corrosive, inflammable, explosive, or other liquid or substance of any kind harmful to the drainage system may be discharged therein unless subject to an approved method of treatment. Acid or alkaline wastes should be previously neutralized. All piping, fittings, traps and connections carrying the untreated wastes must be of special material suited to resist damage. No waste water must discharge into the building sewer at a temperature above 140° F.

The Main Trap

This trap, if used, is placed in the house drain just within the foundation walls. It is a running trap and should have at least one clean-out hole. The purpose of the trap is to isolate the house-drainage system from the sewer, particularly to prevent passage of sewer air into the house system. If it be used, a fresh air inlet is necessary, running from the house side of the main trap to the outer air. The fresh air inlet allows circulation of air through the house drain into the stacks and vent pipes. The disadvantages of this trap have been discussed before.

Changes in Direction

Changes in direction of pipes are made by the use of 45° wyes, half wyes, long or short sweep quarter bends, sixth, eighth, or sixteenth bends, or by a combination of these or equivalent fittings. Single and double sanitary tees and short quarter bends may be used in soil and waste lines only where the change in direction of flow is from horizontal to the vertical. Tees, crosses, and short quarter bends may be used in the vent pipes.

Joints

All joints and connections must be made gas tight as well as watertight. Joints in cast-iron bell and spigot soil pipe known as calked joints are made by firmly packing the opening between the bell and spigot with oakum or hemp and then pouring in, in one pouring, pure hot lead to a depth of not less than 1 inch. The lead is then tamped or calked so that the joint will be tight. No paint, varnish, or putty is permitted until after the joint is tested. In joining wrought iron, steel, or brass to cast iron, either screwed or calked joints are used. When joining lead pipe to cast iron, steel, or wrought iron, the joint should be made by means of wiped joints to a calking ferrule, soldered nipple, or bushing. Joints in lead pipe or fittings, or between lead and ferrules, or with brass or copper pipe solder nipples, bushings, or traps, should be full wiped joints, with an exposed surface on each side of the joint of not less than 3/4 inch and the minimum thickness at the thickest part of the joint of not less than 3/8 inch. Joints in vitrified tile pipe are usually made with cement. A gasket of jute or oakum is soaked in cement grout and placed around the end of the spigot of the pipe to be laid. After the spigot has been placed in position in the bell, the joint is filled and firmly compacted with 1:3 cement mortar.

Joints in concrete sewer pipe or between such pipe and metal pipe should be made with approved hot-poured jointing material or with cement joints as described above.

Pipes Through Roof or Walls

Where pipes pass through a roof or exterior wall, the opening should be watertight.

Water Closet, Pedestal Urinal, and Trap Standard Service Sink

The connections between these fixtures and their drainage pipes should be made of brass, hard lead or iron flanges, calked, soldered or screwed to the drainage pipe. The connection should be bolted to the earthenware by means of red-brass bolts with an approved gasket or washer or setting compound between the earthenware and the connection. The flow flange should be set on an approved firm base. (see Fig. 19.)

Venting Systems

No vents are less than 1 1/4 inches in diameter. For 1 1/4 and 1 1/2 inch wastes, the vents are the same diameter as the waste pipes. Branch vents on main vents should never be less than half the diameter of the soil or waste pipe they are venting, but in no case less than 1 1/2 inches in case of a vent stack or main vent. The size of main vents and vent stacks is based upon the size of the waste or soil stack, the number of fixtures or closets connected, and the actual length of the vent or vent stack.

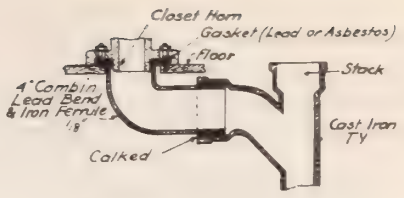


Fig. 19. Water Closet Connection

Table 10 Size and length of vents

Size of soil or waste stack	Total fixtures connected to stack	Diameter of vent (inches)										
		1¼	1½	2	2½	3	4	5	6	8	10	12
		(Maximum length of vent given in feet)										
1¼	2	30	---	---	---	-----	---	---	-----	---	---	---
1½	8	50	150	---	---	-----	---	---	-----	---	---	---
1¼	10	30	100	---	---	-----	---	---	-----	---	---	---
2	12	30	75	200	---	-----	---	---	-----	---	---	---
2	20	26	50	150	---	-----	---	---	-----	---	---	---
2½	42	---	30	100	300	-----	---	---	-----	---	---	---
3	10	---	42	145	355	1,040	---	---	-----	---	---	---
3	21	---	32	110	270	805	---	---	-----	---	---	---
3	53	---	27	94	230	680	---	---	-----	---	---	---
3	102	---	25	86	210	620	---	---	-----	---	---	---
4	43	---	---	35	85	250	975	---	-----	---	---	---
4	140	---	---	27	65	195	750	---	-----	---	---	---
4	320	---	---	23	55	165	635	---	-----	---	---	---
4	530	---	---	21	50	150	580	---	-----	---	---	---
5	190	---	---	---	28	82	320	985	-----	---	---	---
5	490	---	---	---	21	63	245	760	-----	---	---	---
5	940	---	---	---	18	53	207	670	-----	---	---	---
5	1,400	---	---	---	16	49	189	585	-----	---	---	---
6	500	---	---	---	---	33	130	400	1,000	---	---	---
6	1,100	---	---	---	---	26	100	310	775	---	---	---
6	2,000	---	---	---	---	22	84	260	655	---	---	---
6	2,000	---	---	---	---	20	77	240	595	---	---	---
8	1,800	---	---	---	---	-----	31	95	240	940	---	---
8	3,400	---	---	---	---	-----	24	73	185	720	---	---
8	5,600	---	---	---	---	-----	20	62	155	610	---	---
8	7,600	---	---	---	---	-----	18	56	140	555	---	---
10	4,000	---	---	---	---	-----	---	31	78	305	960	---
10	7,200	---	---	---	---	-----	---	24	60	235	735	---
10	11,000	---	---	---	---	-----	---	20	51	200	625	---
10	15,000	---	---	---	---	-----	---	18	46	180	570	---
12	7,300	---	---	---	---	-----	---	---	31	120	380	940
12	13,000	---	---	---	---	-----	---	---	24	94	295	720
12	20,000	---	---	---	---	-----	---	---	20	79	250	610
12	26,000	---	---	---	---	-----	---	---	18	72	225	555
15	15,000	---	---	---	---	-----	---	---	-----	40	125	305
15	25,000	---	---	---	---	-----	---	---	-----	31	96	235
15	38,000	---	---	---	---	-----	---	---	-----	26	81	200
15	50,000	---	---	---	---	-----	---	---	-----	24	74	180

Stack Vents

At least one of the stacks of the plumbing system must extend full size through the roof for the following purposes:

a) Ventilation and carrying of the sewer air above the roof.
b) Prevent siphoning of the traps by suction.
c) Prevent possibility of a back pressure forcing the seals of the fixture traps.

The stack vent must be terminated at least 6" above the roof and properly flashed. In sections of the country subjected to snow accumulation vent extensions must be high enough to clear any possible accumulation of snow. Where the roof serves any purpose other than weather protection, the extension must run at least 6 feet above the roof.

Circuit and Loop Vents (Figs. 22 and 24)

A branch soil or waste pipe to which two and not more than eight water closets (except blow-out type), pedestal urinals, trap standard service sinks, shower stalls, or floor drains are connected in battery, may be vented by a circuit or loop vent which must take off in front of the last fixture connection. When other fixtures discharge above such branch, each branch must be provided with a relief vent taken off in front of the first fixture connection.

Two circuit vented horizontal branches with the maximum load of 8 water closets may have a dual relief vent. The point of junction of both circuit vents must be at least 6 inches above the flood level rim of the highest fixture connected.

Traps and Trap Vents

The function of traps has been discussed elsewhere. The following specifications govern the use of traps.

Each plumbing fixture, excepting those having integral traps, must be separately trapped by a water seal trap, placed as close as possible to the fixture outlet. However, a combination plumbing fixture may be installed on a trap, if one fixture be not more than 6 inches deeper than the other and the waste outlets be not more than 30 inches apart. Likewise, a single trap may be installed for a set of not more than three single compartment laundry trays or three lavatories immediately adjacent to each other in the same room and the waste outlets are not more than 30 inches apart, and the trap is centrally located.

The water seal must not be less than 2 inches nor more than 4 inches. Each fixture trap must have a protecting vent so located that the slope and the developed length in the fixture drain from the trap weir to the vent fitting are as indicated in the following table:

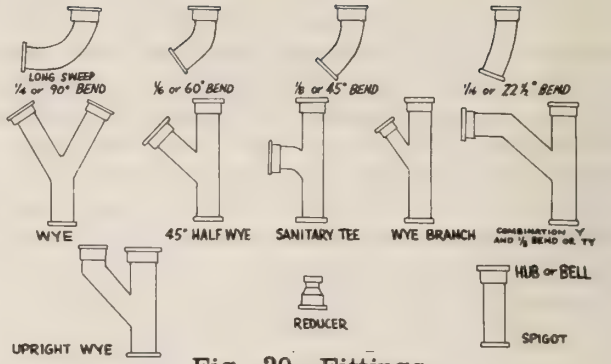


Fig. 20. Fittings

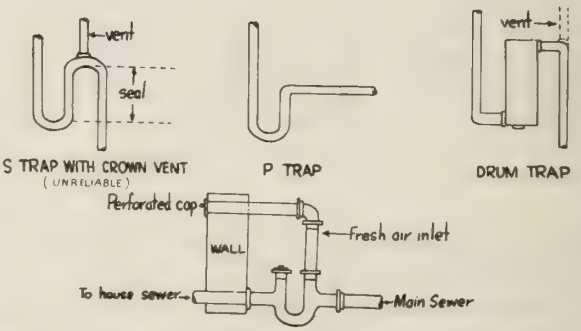


Fig. 21. Main Trap with Fresh Air Inlet. Drum traps are somewhat more resistant to siphonage than S or P traps but do not give so good a scouring velocity. They must have vents.

Table 11 Distance of Trap from Vent

Size of Fixture Drain in inches	Permissible Distance of Trap from Vent Sanitary Tee	
	1/4" slope	1/2" slope
1 1/4	4' - 0"	2' - 6"
1 1/2	4' - 6"	3' - 0"
2	5' - 0"	4' - 6"
3	6' - 0"	6' - 0"
4	8' - 0"	8' - 0"

The vent pipe opening from a waste or soil pipe, except for water closets and similar fixtures, must not be below the dip of the trap. Likewise, no back vent should be installed within two pipe diameters of the trap weir (crown venting, Fig. 23).

Pipe Supports

Since cast-iron stacks and soil pipes are jointed with lead, it is important that they be properly supported, otherwise changes in alignment may occur that will cause leaks. Vertical stacks should be supported at their bases by brick or concrete piers and at each floor a wrought-iron strap should be placed just below the bell of the joint or branch of a fitting securely fastening the pipe to a rafter or vertical timber. Each joint of a horizontal line should be supported in some way; if overhead, by straps, if close to the floor or ground, by piers or special supporting fittings. Support intervals should not be over 5 feet for cast iron soil pipe and not over 10 feet for other piping. Pipes in the ground must be laid in a firm bed over their entire length.

A soil or waste pipe or building drain passing under a footing or through a foundation wall must be provided with a relieving arch, or pass through an iron pipe sleeve built into the masonry wall two pipe sizes greater than the pipe passing through. All exterior openings provided for the passage of piping must be sealed with fitting collars of metal or other rat-proof material.

Inspections and Tests

The first inspection is made after the "roughing in", i.e., when all the work has been done up to the setting of the fixtures and with all the piping open to view. Usually at this time the water test is given. All of the openings except the top of the stack are closed by caps, soldering, or special plugs, and the complete system is filled until water flows from the top of the stack, but no section shall be tested with less than 10 feet head of water. In testing successive sections, at least the upper 10 feet of the next preceding section should be tested, so that no joint or pipe in the building (except the uppermost 10 feet of the system) should have been submitted to a test of less than 10 feet head of water. The water must be kept in the system, or in the portion under test, for at least 15 minutes before inspection starts; the system must be tight at all points. This test is called the water test. An alternative is the air test.

The air test is made by attaching an air compressor or testing apparatus to any suitable opening and after closing all other inlets and outlets to the system, forcing air into the system until there is a uniform gage pressure of 5 lbs. per square inch or sufficient to balance a column of mercury 10 inches in height. This pressure must be held without introduction of air for a period of at least 15 minutes.

The final test is made after the plumbing fixtures have been set and their traps filled with water. It may be either a smoke test or a peppermint test. Where the smoke test is preferred, it should be made by filling all traps with water and then introducing into the entire system a pungent, thick smoke produced by one of more smoke machines. When the smoke appears at stack openings on the roof they should be closed and a pressure equivalent to a 1 inch water column should be built and maintained for 15 minutes before inspection starts. Where the peppermint test is preferred, 2 oz. of peppermint oil should be introduced for each line or stack.

Upon completion of a section or of the entire water supply system it must be tested and proved tight under a water pressure not less than the working pressure under which it is to be used, the water used for the test to be obtained from the normal source of supply.

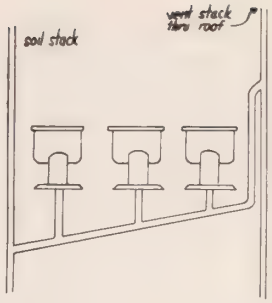


Fig. 22. Circuit Venting. This is used in instances similar to that of loop venting.

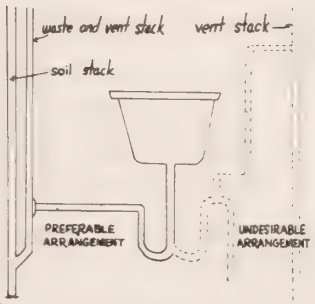


Fig. 23. Crown Venting. This vent runs from the crown of the individual trap to the vent stack.

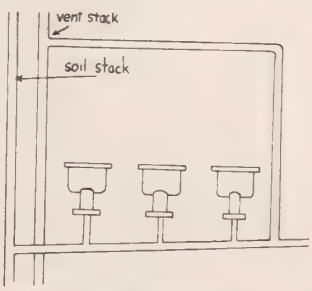


Fig. 24 Loop Venting. This is used in case of a closet which is too far from the waste stack to be vented by it.

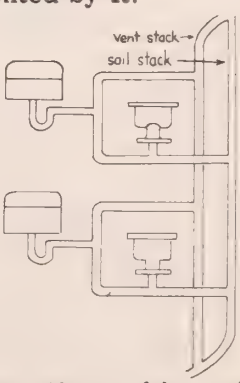


Fig. 25. Continuous Venting. This system is adopted in houses of two or more floors. It should be noted that the vent stack should connect with the main stack at the bottom at an acute angle.

Table 12 Size of Vent Stacks

Number of wet-vented fixtures	Diameter of vent stacks Inches
1 or 2 bathtubs or showers	2
3 to 5 bathtubs or showers	2 1/2
6 to 9 bathtubs or showers	3
10 to 16 bathtubs or showers	4

Table 13 Stack sizes for bedpan steamers and boiling type sterilizers
(Number of connections of various sizes permitted to various sized sterilizer vent stacks)

	Stack size	Connection size 1 1/2"	2"
1 1/2 - inch[1]		1 or	0
2 - inch[1]		2 or	1
2 - inch[2]		1 and	1
3 - inch[1]		4 or	2
3 - inch[2]		2 and	2
4 - inch[1]		8 or	4
4 - inch[2]		4 and	4

1. Total of each size.
2. Combination of sizes.

Table 14 Stack sizes for pressure sterilizers
(Number of connections of various sizes permitted to various sized vent stacks)

		Connection size 3/4"	1"	1 1/4"	1 1/2"
1 1/2 - inch[1]		3 or	2 or	1	
1 1/2 - inch[2]		2 and	1		
2 - inch[1]		6 or	3 or	2 or	1
2 - inch[2]		3 and	2		
2 - inch[2]		2 and	1 and	1	
2 - inch[2]		1 and	1 and		1
3 - inch[1]		15 or	7 or	5 or	3
3 - inch[2]			1 and	2 and	2
3 - inch[2]		1 and	5 and		1

1. Combination of sizes.
2. Total of each size.

Table 15 Minimum flow pressure and flow rates

Location	Flow Pressure, p. s. i.	Flow rate, g. p. m.	Location	Flow pressure p. s. i.	Flow rate, g. p. m.
Ordinary basin faucet	8	2.0	Shower	8	5.0
Self-closing basin faucet	8	2.5	Ball-cock for closet	8	3.0
Sink faucet, 3/8 inch	8	4.5	Flush valve for closet	15	15.35
Sink faucet, 1/2 inch	8	4.5	Flushometer valve for urinal	15	15.0 *
Bathtub faucet	8	6.0	Drinking fountains	15	0.75
Laundry tub cock, 1/2 inch	8	5.0	Sill cock--wall hydrant	10	5.0

*Wide range due to variation in design and type of closet flush valves.

Table 16 Minimum number of plumbing fixtures

Type of building occupancy	Type of fixture					
	Water closets	Urinals	Lavatories	Bathtubs or showers	Drinking fountains	Other fixtures
Assembly - places of worship.	Number of persons / Number of fixtures 150 Women --- 1 300 Men --- 1	Number of persons / Number of fixtures 300* --- 1	1 ---	---	1 ---	
Assembly - other than places of worship (auditoriums, theaters, convention halls).	Number of persons / Number of fixtures 1-100 --- 1 101-200 --- 2 201-400 --- 3 Over 400, add 1 fixture for each additional 500 men and 1 for each 300 women.	Number of persons / Number of fixtures 1-200 --- 1 201-400 --- 2 401-600 --- 3 Over 600, add 1 fixture for each 300 mrn.*	Number of persons / Number of fixtures 1-200 --- 1 201-400 --- 2 401-750 --- 3 Over 750, add 1 fixture for each 500 persons.	---	1 for each 300 persons.	1 slop sink.
Dormitories - school or labor, also institutional.	Men: 1 for each 10 persons. Women: 1 for each 8 persons.	1 for each 25 men. Over 150, add 1 fixture for each 50 men.*	1 for each 12 persons. (Separate dental lavatories should be provided in community toilet rooms. A ratio of 1 dental lavatory to each 50 persons is recommended.)	1 for each 8 persons. For women's dormitories, additional bathtubs should be installed at the ratio of 1 for each 30 women. Over 150 persons add fixture for each 20 persons.	1 for each 75 persons--	Laundry trays, 1 for each 50 persons. Slop sinks, 1 for each 100 persons.
Dwellings - one and two family.	1 for each dwelling unit.	---	1 for each dwelling unit.	1 for each dwelling unit.	---	Kitchen sink 1 for each dwelling unit.
Dwellings - multiple or apartment.	1 for each dwelling unit or apartment.	---	1 for each dwelling unit.	1 for each dwelling unit or apartment.	---	Kitchen sink 1 for each dwelling unit or apartment. For apartments or multiple dwelling units in excess of 10 apartments or units, 1 double laundry tray for each 10 units or 1 automatic laundry washing machine for each 20 units.
Industrial-factories, warehouses, foundries, and similar establishments.	Number of each sex / Number of fixtures 1-10 --- 1 11-25 --- 2 26-50 --- 3 51-75 --- 4 76-100 --- 5 1 fixture for each additional 30 employees.	Where more than 10 men are employed: Number of men / Number of urinals 11-30 --- 1 31-80 --- 2 81-160 --- 3 161-240 --- 4	Number of persons / Number of fixtures 1-100 --- 1 to 10 persons. Over 100 --- 1 to 15 persons	1 shower for each 15 persons exposed to excessive heat or to occupational hazard from poisonous, infectious or irriation material.	1 for each 75 persons.	
Institutional-Other than hospitals or penal institutions (on each occupied story.)	1 for each 25 men --- 1 for each 20 women.	1 for each 50 men*--	1 for each 10 persons	1 for each 10 persons	1 for each 50 persons.	
Hospitals --- Individual room wards Waiting rooms --- Employees ---	1 --- 1 for each 8 patients 1 --- Same as public ---	--- --- --- Same as public ---	1 --- 1 for each 10 patients 1 --- Same as public ---	1 --- 1 for each 20 patients --- ---	--- 1 for each 100 patients --- Same as public ---	1 slop sink per floor.
Penal institutions - Prisoners --- Employees ---	1 in each cell --- 1 in each exercise room--- Same as public ---	1 in each exercise room --- --- Same as public ---	1 in each cell --- 1 in each exercise area --- Same as public ---	1 on each cell block floor. --- ---	1 on each cell block floor. 1 in each exercise area. Same as public ---	1 slop sink per floor.
Public buildings, offices, business, mercantile, storage, and institutional employees.	Number of each sex / Number of fixtures 1-15 --- 1 16-35 --- 2 36-55 --- 3 56-80 --- 4 81-110 --- 5 111-150 --- 6 1 fixture for each additional 40 employees.	Urinals may be provided in men's* toilet rooms in lieu of water closets but for not more than 1/3 of the required number of water closets.	Number of employees / Number of fixtures 1-15 --- 1 16-35 --- 2 36-60 --- 3 61-90 --- 4 91-125 --- 5 1 fixture for each additional 45 persons.	---	1 for each 75 persons --	1 slop sink per floor.
Schools: Elementary --- Secondary ---	Boys / Girls 1/40 / 1/35 1/75 / 1/45	1/30 boys --- 1/30 boys ---	1/50 pupils --- 1/50 pupils ---	In gym or pool shower rooms, 1/5 Pupils of a class.	1/100 pupuils but at least 1 per floor.	Slop sinks, 1 on each floor.
Working men, temporary facilities.	1/30 working men----	1/30 working men ----	1/30 working men ----		1 fixture or equivalent for each 100 working men.	

* Where urinals are provided for the women, the same number shall be provided as for men.

It is possible to make simple tests for the purpose of discovering whether traps are sealed or not. If knocking in the pipe results in a hollow sound it will probably mean that the trap seal has been lost. A still better method is to hold a match at the entrance to the waste pipe. Flickering will indicate a loss of the trap seal.

Testing Procedures for Backflow Preventers

Vacuum Breaker, Atmospheric. Normal failure of an atmospheric type vacuum breaker is the result of a rupture of the rubber membrane in devices using the rubber check valve, or the result of damage or failure of the disc in the disc type devices. This type of failure is usually accompanied by an excessive weeping or leakage of the device and can readily be determined through visual examination. In addition to visual inspection, some of the units should be disassembled periodically for inspection.

Reduced Pressure Principle Backflow Preventer. The reduced pressure principle backflow installation should include a tight closing gate valve at each end of the device.

Four threaded 1/2-inch test cocks should be installed as indicated in figure 26.

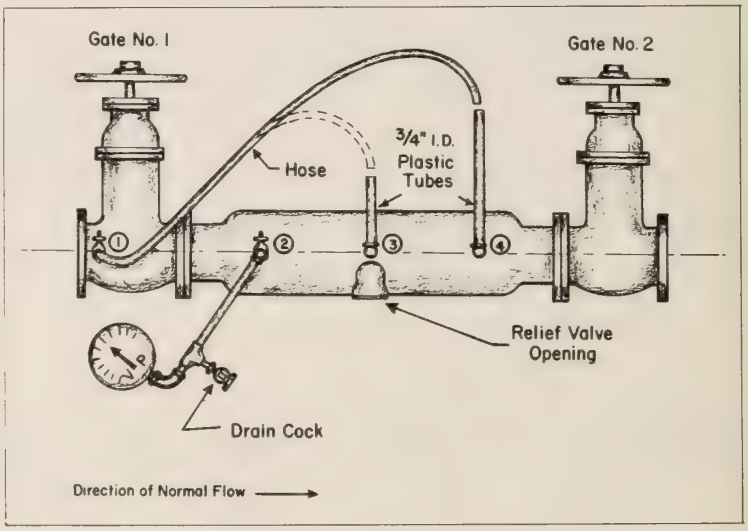


Fig. 26. Reduced Pressure Principle: Backflow Preventer Field Test

Additional equipment required to conduct the tests is as follows:

1. One Compound gage capable of indicating a vacuum equal to 30 inches of mercury or about 15 psi (pounds per square inch).
2. One Plastic tube 1 inch O. D. (outer diameter) x 3/4-inch I. D. (inner diameter) x 6 inches long with an adapter to 1/2-inch pipe thread and a 1/2-inch street ell.
3. One Plastic tube as above, 12 inches long with adapter and street ell.
4. One Compound gage and connecting piping with drain cock as shown on the diagram.
5. One Eight-foot length of 1/4-inch hose with an adapter to 1/4-inch pipe.

In the operation of the RPPBP, the reduced pressure zone between the two check valves is maintained at a pressure less than the supply line pressure by the action of the relief valve. The relief valve should be capable of maintaining a reduced pressure zone, which is at least 2 psi less than the supply pressure. Both check valves should close tightly against backflow under adverse pressure differentials.

Test Procedure. Attach equipment as shown in the diagram.

A. Close gate valve No. 2. If the relief valve starts to drain, the first check valve is leaking.

B. Close gate valve No. 1.

C. Open test cock No. 4 to fill the plastic tube, and crack open gate valve No. 1, until a small dribble continues over the top of the tube.

D. Open test cock No. 3. Water will then spill over the top of the short tube.

E. Open test cock No. 2.

F. Open the drain cock No. 1 slowly until the spillage over the top of the short tube stops. Check the gage reading at this point. This reading is the pressure drop across the first check valve and should be not less than 6 psi nor more than 11 psi.

G. Slowly open the drain cock, thereby causing the gage pressure to fall.

H. As the gage pressure approaches 2 psi, the water column in tube No. 3 will slowly fall, and should rapidly fall just as the relief valve opens. (In valves 6 inches and larger, it may be necessary to refill tube with hose.) The gage reading at this point should not be less than 2 psi.

I. Open the drain cock wide, causing relief valve to open wide.

J. If the water level in the tube at test cock No. 4 remains at top of tube, the check valve No. 2 is tight. If the water level falls when the relief valve is open, refill No. 4 tube with the hose and maintain the water level at the top of the tube. If the relief valve drains continually, the second check valve is leaking. If there be no drainage from the relief valve, but flow through the hose is required to maintain water level in the No. 4 tube, then the second gate valve is leaking.

Double Check-Double Gate Valves. The double check-double gate valve assembly should include test hose-bibbs as shown in figure 26. A method for testing the check valves is as follows:

A. Where Back-Pressure is Available on Private Supply:

1. Open all test hose bibbs individually to flush out any sediment or scale.
2. Close gate valves A and G.
3. Open test hose bibbs B and F, successively. If leakage occurs, gate valve(s) A and/or G are leaking and must be repaired before continuing test.
4. If no leakage at test hose bibbs B and F with gate valves A and G closed, proceed with the following:

a. Open gate valve G and test hose bibb D. If leakage does not cease, check valve E is leaking and must be repaired. If leakage ceases, check valve E is tight.

b. Temporarily connect a hose between test hose bibbs D and F and open these hose bibbs. Open test hose bibb B. If leakage does not cease, check valve C is leaking and must be repaired. If leakage ceases, check valve C is tight.

c. If check valves are repaired, repeat the test as above.

5. When the test is complete, close test hose bibbs and remove the hose. Leave gate valves A and G in their proper position.

B. Where Insufficient Backpressure is Available on Private Supply:

1. Open all test hose bibbs individually to flush out any sediment or scale.
2. Close gate valves A and G.
3. Open test hose bibbs B and F, successively. If leakage occurs, gate valve(s) A and/or G are leaking and must be repaired before continuing test.
4. If no leakage at test hose bibbs B and F with gate valves A and G closed, proceed with the following:

a. Temporarily connect a hose between test hose bibbs J and F and open test hose bibbs. Open test hose bibb D. If leakage does not cease, check valve E is leaking and must be repaired. If leakage ceases, check valve E is tight.

b. Close hose bibbs J and F. Temporarily connect the hose between test hose bibbs J and D and open these test hose bibbs. Open test hose bibb B. If leakage does not cease, check valve C is leaking and must be repaired. If no leakage occurs, check valve C is tight.

c. If check valves are repaired, repeat the test as above.

5. When the test is complete, close test hose bibbs and remove the hose. Leave gate valves A and G in their proper position.

Sizing the Water Supply Systems

The detailed design of a water distribution system lies entirely beyond the scope of this manual and should be done by persons trained for this work. It is possible, however, in some instances to make a fairly accurate estimate for the main water intake line, without such training, using the graphs given for this purpose; and such knowledge may be useful for the sanitarian and enable him, in some instances, to discover the reason why a certain water supply system does not give satisfactory service and why pressures are far below those needed.

The size of water main needed for satisfactory operation of a distribution system in a building is, of course, dependent on the number and kind of fixtures it serves, and which are, more or less, used simultaneously. Extensive research has been done on this matter at the University of Iowa and by the U. S. Bureau of Standards, which research is the basis of the method given below.

In this method the various fixtures have been given a "Demand Weight", based upon the amount of water needed for one lavatory, which have been given a demand weight of 1. For our purpose these demand weights are equal to the figures for fixture units given in the table earlier in this chapter, except that where tanks are used for water closets the number of units for one bathroom pump is 6, instead of 8. (For supply outlets likely to impose continuous demand, this continuous supply should be estimated separately and added to the total demand for fixtures). The demands are expressed in fixture units. The number of each fixture is multiplied by its fixture unit equivalent: these amounts, added, will give the total load in fixture units on the pipe.

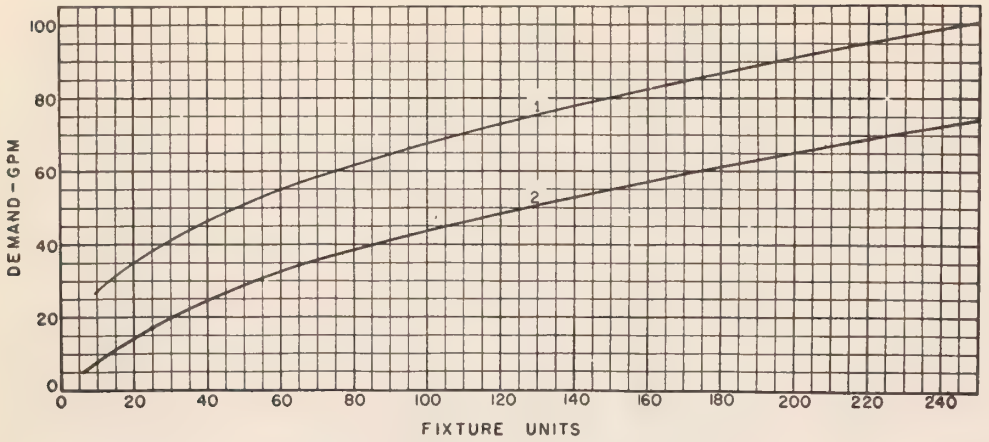
Chart 11 shows for a total of fixture units up to 240 the corresponding amount in gallons per minute, based upon these numbers and the probable simultaneous use of these fixtures. Where flush valves are used on the water closets, the demand is more than where tanks are used, up to a total of 1000 fixture units. Example: Taking the number of fixtures in a 2 story dwelling house with basement, we have the following:

Basement:	Combination sink and laundry tray		3 units
	Mechanical washer (estim.)		3 "
First floor:	Water closet with tank		3 "
	Lavatory		1 "
	Kitchen sink		2 "
Second Floor:	Water closet)		
	Lavatory)	Bathroom group	6 "
	Bath tub)		
			18 units

Suppose that we have an additional outlet in the yard and a lavatory in the garage, the total would be 20 units. Chart 1 gives a water demand of 14 g. p. m. for 20 units, using tanks; whereas the demand would be 35 g. p. m. if flush valves had been used.

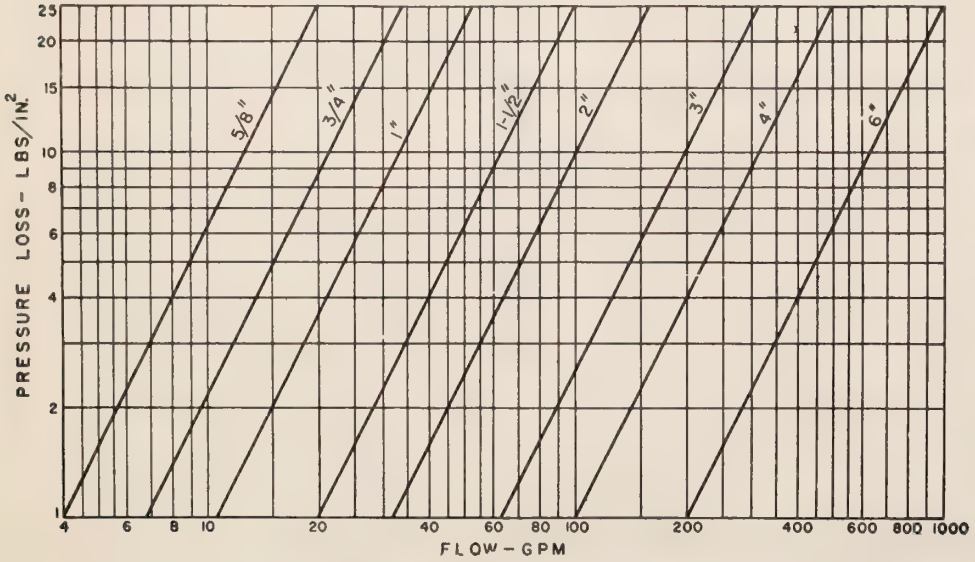
The necessary size for the water main is taken from Chart 2, which is based upon the flow of water in "fairly rough pipes", including used piping which has not appreciably corroded. In this chart the horizontal lines correspond with the flow in gallons per minute. Let us take the horizontal line for the flow of 15 gallons per minute. This line intersects several (heavy) sloping lines which belong to the various possible pipe sizes. We see that it cuts sizes from 2 1/2 inch to 3/4 inch included. The use of a 2" pipe would cause a friction loss of 0. 35 lbs.* per square inch to the pressure in the pipe; the use of a 3/4" pipe, a loss of 45 lbs.* per square inch, as indicated by the vertical lines through the intersection of the horizontal line at 15 g. p. m. with the sloping lines for the pipe sizes.

*Note: This friction loss is for a 100 foot length pipe.



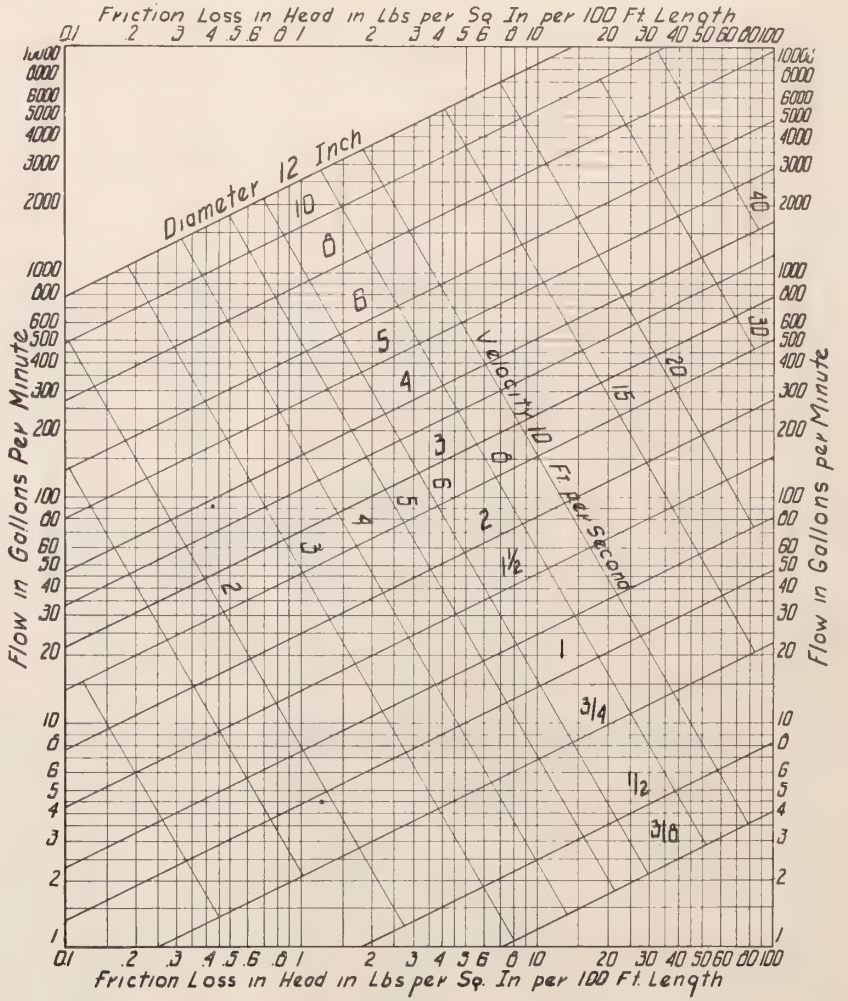
Enlarged Scale Demand Load

Chart 1



Pressure Losses in Disk-type Water Meters

Chart 3



Flow Chart for Fairly Rough Pipe

Chart 2

Since we should choose the smallest satisfactory pipe size, let us see if the 3/4" size would be satisfactory.

First, we want to know if a 3/4" water meter allows a flow of 15 g.p.m. The normal test-flow limits for disk type meters for various sizes are:

5/8"	- 1 to	20	g.p.m.
3/4"	- 2 to	34	"
1"	- 5 to	53	"
1 1/2"	- 5 to	100	"
2"	- 8 to	160	"
3"	- 16 to	315	"
4"	- 28 to	500	"
6"	- 48 to	1000	"

which shows that the capacity of the meter is ample.

Second, we must find the loss of pressure for a flow of 15 g.p.m. for a 3/4" disk type meter. Chart 3 gives this as 5 lbs. per square inch for this size disk type meter.

Third, we must consider the loss of pressure in the riser pipe to the highest branches. Assuming this in our case to be 25 feet, the loss for elevation is 25 x 0.434* = about 11 lbs. per square inch. Likewise, there will be losses for elbows and tees, but in our case these will be negligible. The total loss so far is thus 16 lbs. per square inch. Let us suppose that the pipe takes off from the city main at a distance of 55 feet from the riser pipe. The total length of the pipe is therefore 55+25 = 80 feet. Using a 3/4" pipe, the loss of head will be 80/100 x 45 lbs. = 36 lbs. The grand total of loss will be 16+36 = 52 lbs. from the city main to the highest fixture. Whether or not this loss can be tolerated depends entirely on the minimum normal pressure in the city main. If this be 65 lbs. per square inch, the resulting pressure would be 13 lbs. per square inch, and a 3/4" line could be used, but not for flush valves on the water closets which need a pressure of 15 lbs. If the minimum pressure in the main be 50 lbs. or less, a 1" line should be taken instead. It should be pointed out in this case that the long distance of the riser pipe from the water main is the cause for this condition. If this distance were 35 feet less, the loss of head in a 3/4" pipe would be 15 lbs. less or 37 lbs., leaving a margin of 13 lbs. at a pressure of 50 lbs. in the city main. A 3/4" line would then be entirely suitable. The calculation of the size of branch lines follows the same procedure outlined above. For the usual one to two floor homes close to the street and the city main, a 5/8" meter and main supply line and 1/2" branch lines are generally satisfactory.

Cross-Connection Control Ordinance Provisions

Introduction

The successful promotion of a cross-connection and backflow connection control program in a municipality will be dependent upon legal authority to conduct such a program. Where a community has adopted a modern plumbing code such as the National Plumbing Code, ASA A40.8--1955 or subsequent revisions thereof, provisions of the code will govern backflow and cross-connections. It then remains to provide an ordinance which will establish a program of inspection for an elimination of cross and backflow connections within the community. Frequently authority for such a program may already be possessed by the water department or water authority. In such cases no further document may be needed. A cross-connection control ordinance should have at least three basic parts.

1. Authority for establishment of a program.
2. The technical provisions relating to eliminating backflow and cross-connections, and
3. Penalty provisions for violations.

The following simple form is suggested for municipalities which desire to adopt a cross-connection control ordinance. The technical provisions are excerpted from a revision of the

*Note: If a cubic foot of water weighs 62.4 lbs., then a column of water 12 inches high and 1 inch square in thickness would have a weight of 62.4 144 = 0.434.

National Plumbing Code prepared by the Public Health Service Technical Committee on Plumbing Standards. Where the National Plumbing Code or subsequent revisions thereof is in effect, the technical sections of the following can be replaced by a statement of reference to the Code. Communities adopting ordinances should check with State Health Officials to assure conformance with state codes. The form of the ordinance should comply with local legal requirements.

Ordinance For the Control of Backflow and Cross-Connections

Section 1. Authority

Responsibility of the Director. The Director, Department of _____, or his designated agent, shall inspect the plumbing in every building or premises in this City as frequently as in his judgment may be necessary to ensure that such plumbing has been installed in such a manner as to prevent the possibility of pollution of the water supply of the city by the plumbing. The director shall notify or cause to be notified in writing the owner or authorized agent of the owner of any such building or premises, to correct, within a reasonable time set by the Director, any plumbing installed or existing contrary to or in violation of this ordinance, and which is his judgment, may, therefore, permit the pollution of the city water supply, or otherwise adversely affect the public health.

Inspection. The Director, or his designated agent, shall have the right of entry into any building, during reasonable hours, for the purpose of making inspection of the plumbing systems installed in such building or premises provided that with respect to the inspection of any single family dwelling, consent to such inspection shall first be obtained from a person of suitable age and discretion therein or in control thereof.

Section 2. Definitions. See section of Definitions at the beginning of this chapter. For other definitions, see other chapters.

Section 3. General (Technical) Requirements

General. A potable water supply system shall be designed, installed and maintained in such manner as to prevent contamination from nonpotable liquids, solids or gases, from being introduced into the potable water supply through cross-connections or any other piping connections to the system.

Cross-Connections Prohibited. Cross-connections between potable water systems and other systems or equipment containing water or other substances of unknown or questionable safety are prohibited except when and where, as approved by the authority having jurisdiction, suitable protective devices such as the reduced pressure zone backflow preventer or equal are installed, tested and maintained to insure proper operation on a continuing basis.

Interconnections. Interconnection between two or more public water supplies shall be permitted only with the approval of the health authority having jurisdiction.

Individual Water Supplies. Cross-connections between an individual water supply and a potable public supply shall not be made unless specifically approved by the health authority having jurisdiction.

Connections to Boilers. Potable water connections to boiler feed water systems in which boiler water conditioning chemicals are introduced shall be made through an airgap or provided with an approved backflow preventer* located in the potable waterline before the point where such chemicals are introduced.

Prohibited Connections to Fixtures and Equipment. Connection to the potable water supply system for the following is prohibited unless protected against backflow as set out herein.

(a) Bidets.

(b) Operating, dissection, embalming, and mortuary tables or similar equipment--in

*Reduced pressure principle or double check-double gate valves.

such installation the hose used for water supply shall terminate at least 12 inches away from every point of the table or attachments.

(c) Pumps for nonpotable water, chemicals or other substances--priming connections may be made only through an airgap.

(d) Building drainage, sewer or vent systems.

(e) Any other fixture of similar hazard.

Refrigerating Unit Condensers and Cooling Jackets. Except where potable water provided for a refrigerator condenser or cooling jacket is entirely outside the piping or tank containing a toxic refrigerant, with two separate thickness of metal separating the refrigerant from the potable water supply, inlet connection shall be provided with an approved check valve. Also adjacent to and at the outlet side of the check valve, an approved pressure relief valve set to relieve at 5 psi (pounds per square inch) above the maximum water pressure at the point of installation shall be provided if the refrigeration units contain more than 20 pounds of refrigerants.

Protection Against Backflow and Backsiphonage.

Water Outlets. A potable water system shall be protected against backflow and backsiphonage by providing and maintaining at each outlet:

(a) Airgap: An airgap as specified herein between the potable water outlet and the flood level rim of the fixture it supplies or between the outlet and any other source of contamination, or

(b) Backflow Preventer: An approved backflow preventer device or vacuum breaker to prevent the drawing of contamination into the potable water system.

Minimum Required Airgap. (a) How Measured: The minimum required airgap shall be measured vertically from the lowest end of a potable water outlet to the flood rim or line of the fixture or receptacle into which it discharges.

(b) Size: The minimum required airgap shall be twice the effective opening of a potable water outlet unless the outlet be a distance less than three times the effective opening away from a wall or similar vertical surface in which cases the minimum required airgap shall be three times the effective opening of the outlet. In no case shall the minimum required airgap be less than shown in table 17, "Minimum Airgaps for Generally Used Plumbing Fixtures."

Table 17 Minimum airgaps for generally used plumbing fixtures

Fixture	Minimum airgap	
	When not affected by near wall[1] (inches)	When affected by near wall[2] (inches)
Lavatories and other fixtures with effective openings not greater than 1/2-in. diameter	1.0	1.50
Sink, laundry trays, goose-neck bath faucets and other fixtures with effective openings not greater than 3/4-in. diameter	1.5	2.25
Over rim bath fillers and other fixtures with effective openings not greater than 1-in. diameter	2.0	3.0
Drinking water fountains--single orifice 7/16 (0.437) in. diameter or multiple orifices having total area of 0.150 sq. in. (area of circle 7/16-in. diameter)	1.0	1.50
Effective openings greater than 1 inch	(3)	(4)

1. Side walls, ribs, or similar obstructions do not affect airgaps when spaced from inside edge of spout opening a distance greater than 3 times the diameter of the effective opening for a single wall, or a distance greater than 4 times the diameter of the effective opening for 2 intersecting walls.
2. Vertical walls, ribs, or similar obstructions extending from the water surface to or above the horizontal plane of the spout opening require a greater airgap when spaced closer to the nearest inside edge of spout opening than specified in note 1 above. The effect of 3 or more such vertical walls or ribs has not been determined. In such cases, the airgap shall be measured from the top of the wall.
3. 2 times diameter of effective opening.
4. 3 times diameter of effective opening.

Approval of Devices. Before any device for the prevention of backflow or backsiphonage is installed, it shall have first been certified by a recognized testing laboratory acceptable to the agency Director. Devices installed in a building potable water supply distribution system for protection against backflow shall be maintained in good working condition by the person or

persons responsible for the maintenance of the system.

The agency Director or his designee shall inspect routinely such devices and if found to be defective or inoperative shall require the replacement thereof.

Installation of Devices. (a) Vacuum Breakers: Vacuum breakers shall be installed with the critical level at least 6 inches above the flood level rim of the fixture they serve and on the discharge side of the last control valve to the fixture. No shutoff valve or faucet shall be installed beyond the vacuum breaker. For closed equipment or vessels such as pressure sterilizers, the top of the vessel shall be treated as the flood level rim but a check valve shall be installed on the discharge side of the vacuum breaker.

b. Reduced Pressure Principle Backflow Preventer: A reduced pressure principle type backflow preventer may be installed subject to full static pressure.

c. Devices of all Types: Backflow and backsiphonage preventing devices shall be accessibly located preferably in the same room with the fixture they serve. Installation in utility or service spaces, provided they are readily accessible, is also permitted.

Tanks and Vats-Below Rim Supply. (a) Where a potable water outlet terminates below the rim of a tank or vat and the tank or vat has an overflow of diameter not less than given in Table "Sizes of Overflow Pipes for Water Supply Tanks", the overflow pipe shall be provided with an airgap as close to the tank as possible.

Table 18 Sizes of overflow pipes for water supply tanks

Maximum capacity of water supply line to tank	Diameter of overflow pipe (Inches ID*)	Maximum capacity of water supply line to tank	Diameter of overflow pipe (Inches ID)
0-50 gpm ----------	2	400-700 gpm ----------	5
50-150-gpm ----------	2-1/2	700-1,000 gpm ---------	6
100-200 gpm ----------	3	Over 1,000 gpm ---------	8
200-400 gpm ----------	4		

*ID = Inner diameter

(b) The potable water outlet to the tank or vat shall terminate a distance not less than 1-1/2 times the height to which water can rise in the tank above the top of the overflow. This level shall be established at the maximum flow rate of the supply to the tank or vat and with all outlets except the airgap, overflow outlet closed.

(c) The distance from the outlet to the high water level shall be measured from the critical point of the potable water supply outlet.

Protective Devices Required. Approved devices to protect against backflow and backsiphonage shall be installed at all fixtures and equipment where backflow and/or backsiphonage may occur and where a minimum airgap cannot be provided between the water outlet to the fixture or equipment and its flood level rim.

(a) Connections Not Subject to Back Pressure: Where a water connection is not subject to back pressure, a nonpressure type vacuum breaker shall be installed on the discharge side of the last valve on the line serving the fixture or equipment. A list of some conditions requiring protective devices of this kind is given in Table 19, "Cross-Connections Where Protective Devices are Required and Critical Level (C-L) Settings for Backflow Preventers".

Table 19 Cross-connections where protective devices are required and critical level (C-L) settings for backflow preventers[1]*

Fixture or equipment	Method of installation
Aspirators and ejectors	C-L at least 6 in. above flood level of receptacle served.
Dental units	On models without built-in vacuum breakers--C-L at least 6 in. above flood level rim of bowl.
Dishwashing machines	C-L at least 6 in. above flood level of machine. Install on both hot and cold water supply line.
Flushometers (Closet & Urinal)	C-L at least 6 in. above top of fixture supplies.
Garbage can cleaning machine	C-L at least 6 in. above flood level of machine. Install on both hot and cold water supply lines.
Hose outlets	C-L at least 6 in. above highest point on hose line.
Laundry machines	C-L at least 6 in. above flood level of machine. Install on both hot and cold water supply lines.
Lawn sprinklers	C-L at least 12 in. above highest sprinkler or discharge outlet.
Steam tables	C-L at least 6 in. above flood level.
Tank and vats	C-L at least 6 in. above flood level rim or line.
Trough urinals	C-L at least 30 in. above perforated flush pipe.
Flush tanks	Equip with approved ball cock. Where ball cocks touch tank water equip with vacuum breaker at least 1 in. above overflow outlets. Where ball cock does not touch tank water install ball cock outlet at least 1 in. above overflow outlet or provide vacuum breaker as specified above.
Hose bibbs (where aspirators or ejectors could be connected).	C-L at least 6 in. above flood level of receptacle served.

*Critical Level (C-L) is defined as the level to which the backflow preventer (vacuum breaker) may be submerged before backflow will occur. Where the C-L is not shown on the preventer, the bottom of the device shall be taken as the C-L.

(b) Connections Subject to Back Pressure: Where a potable water connection is made to a line, fixture, tank, vat, pump, or other equipment with a hazard of backflow or backsiphonage where the water connection is subject to back-pressure, and an airgap cannot be installed, the Director may require the use of an approved reduced pressure principle backflow preventer. A partial list of such connections is shown in Table 20, "Partial List of Cross-Connections Subject to Back Pressure".

Table 20 Partial list of cross-connections which may be subject to back pressure.

Chemical lines	Pumps
Dock water outlets	Steam lines
Individual Water supplies	Swimming pools
Industrial process water lines	Tank and vats -- Bottom inlets
Pressure tanks	Hose bibbs

Barometric Loop. Water connections where an actual or potential backsiphonage hazard exists may in lieu of devices specified herein be provided with a barometric loop. Barometric loops shall precede the point of connection.

Double Check-Double Gate Valves. The Director may authorize installation of approved, double check-double gate valve assemblies with test cocks as protective devices against backflow in connections between a potable water system and other fluid systems which present no significant health hazard in the judgment of the Director.

Low Pressure Cutoff Required on Booster Pumps. When a booster pump is used on a water pressure booster system and the possibility exists that a positive pressure of 10 psi (pounds per square inch) or less may occur on the suction side of the pump, there shall be installed a low pressure cutoff on the booster pump to prevent the creation of a vacuum or negative pressure on the suction side of the pump, thus cutting off water to other outlets.

Section 4. Maintenance Requirements

General Requirements. It shall be the responsibility of building and premise owners to maintain all backflow preventers and vacuum breakers within the building or on the premises in good working order and to make no piping or other arrangements for the purpose of bypassing backflow devices.

Reduced Pressure Principle Backflow Preventers. Periodic testing and inspection schedules shall be established by the Director for all reduced pressure type preventers and the interval between such testing and inspections and overhauls of each device shall be established in accordance with the age and condition of the device. Inspection intervals should not exceed 1 year, and overhaul intervals should not exceed 5 years. These devices should be inspected frequently after the initial installation to assure that they have been installed properly and that debris resulting from the installation has not interfered with the functioning of the device. The testing procedures shall be in accordance with the manufacturer's instructions when approved by the Director.

Section 5. Violations and Penalties

Notification of Violation. The Director shall notify the owner, or authorized agent of the owner, of the building or premises in which there is found a violaion of this ordinance, of such violation. The Director shall set a reasonable time for the owner to have the violation removed or corrected. Upon failure of the owner to have the defect corrected by the end of the specified time interval the Director may, if in his judgment an imminent health hazard exists, cause the water service to the building or premises to be terminated, and/or recommend such additional fines or penalties to be invoked as herein may be provided.

Fines. The owner or authorized agent of the owner responsible for the maintenance of the plumbing systems in the building who knowingly permits a violation to remain uncorrected after the expiration of time set by the Director shall, upon conviction thereof by the court, be required to pay a fine of not more than $100 for each violation. Each day of failure to comply with the requirements of the Ordinance, after the specified time provided shall constitute a separate violation.

Suggested Plumbing Ordinance

Introduction

The material presented in this Code does not have legal standing unless it be adopted by reference, or by inclusion, in an act of state, county, or municipal government. Therefore, administration of the provisions of this Code must be preceded by suitable legislation at the level of government where it is desired to use the Code.

In some places in the Code, reference is made to "Administrative Authority." The identity of an Administrative Authority will be established by the act which gives legal standing to the Code provisions. There follows a recommended form for writing an enabling act or ordinance. Its provisions should be modified to suit local conditions.

1 Ordinance

An ordinance to provide standards and regulations as set forth in the National Plumbing Code ASA (number to be assigned) for plumbing installed within the _____ (State, County, Municipality) of _____ (Name) and for the licensing of all plumbers and supervision and inspection of all plumbing within this _____ (State, County, Municipality).

2 Title and Administration

This Code shall be popularly known and cited as the Plumbing Code of the _____ (State, County, Municipality) of _____ (Name) it shall be administered by the _____ (State, County, Municipality) which shall take such action as may be reasonable and necessary to secure compliance with it. The _____ (Name of Administrative Authority) shall appoint such assistants, clerks, and other employees as may be required to administer the Code and fix their compensation.

3 Scope of Ordinance

The provisions set forth in the ordinance shall be in force and effect from this date _____ within the _____ (State, County, Municipality) of _____ (Name).

4 Definitions

4.1. Administrative Authority

Whenever the term Administrative Authority is used in this Code, it shall be construed to mean the _____ (Name of Administrative Authority) or his authorized representative.

4.2. Code

This law, as amended together with any rule or regulation promulgated hereunder by the _____ (Name of Administrative Authority).

4.3. Plumber (Master)

A person who has demonstrated his skill in planning, superintending and installing plumbing and who having satisfied the Examining Board as to his knowledge of the rules and regulations governing the same, and as to his business integrity, has been granted a license as a Master Plumber.

4.4. Plumber (Journeyman)

Any person other than a master or apprentice plumber who has demonstrated to the Examining Board his practical knowledge of the installation of plumbing and has been licensed by the Board to install plumbing under the direction of a Master Plumber.

4.5. Plumber (Apprentice)

A person who: (1) begins his apprenticeship between the ages of 16 and 40; (2) is engaged in learning the plumbing trade by working with and assisting a journeyman or master plumber in the installation, maintenance, and repair of plumbing and drainage; and (3) is covered by an "Apprenticeship Agreement" with a local Joint Apprenticeship Committee.

4.6. Plumbing Inspector

Any journeyman or master plumber who is appointed by the _____ (Name of Administrative Authority) to inspect plumbing within the jurisdiction of the Administrative Authority to determine if the plumbing meets the requirements of the Code.

4.7. Official Copy

A copy of the National Plumbing Code ASA (number to be assigned) marked with the words "_____ (State, County, Municipality) of _____ (Name) Official Copy," and appropriately amended so as to reflect any differences with the Code, shall be deemed to be an official copy of the Code.

5 Plumbing Standards

5.1. Official Copy

Official Copies of the Code to meet the demands, but not less than three, shall be kept on file by the _____ (Name of Administrative Authority), for inspection by and use of the public and may be distributed on demand when available.

6 Board of Plumbing Examiners

6.1. Establishment, Composition, Tenure and Compensation

There is hereby established within the _____ (Name of Administrative Authority) a Plumbing Examining Board, hereafter referred to as the Board, to consist of not less than four members as follows: a representative of the _____ (Name of Administrative Authority), a professional engineer, a master plumber, a journeyman plumber, and a lay member of the voting public. Each technical member of the Board shall have at least 5 years' experience in his respective field, and the lay member shall have been a voting resident of the _____ (State, County, Municipality) of _____ (Name) for at least 5 years. The Board members shall be appointed by _____ (Name of Head of Administrative Authority), to serve for a period of 3 consecutive years. Each Board member except if he be a regular employee of the _____ (Name of Administrative Authority), shall be reimbursed for expenses actually incurred and shall be remunerated on a per diem basis for time actually spent in performance of the functions of the Board at a rate which shall be fixed from time to time by the _____ (Name of Administrative Authority).

6.2. Meeting of the Board

The Board shall meet not more than 30 days following the adoption of this Ordinance, and after at such times as may be necessary for proper performance of its duties, but at least once during any 6 month period.

6.3. Enforcement

The Board is authorized and directed to administer and supervise enforcement of the Code; to provide for such procedures as it may deem necessary to disclose violations; to receive and provide for the investigation of complaints; and to provide for the institution and prosecution of civil or criminal actions or both. To the extent that violation of any provision of the Code creates an imminent danger to health, welfare, or safety, it may be enforced by injunction in any court having jurisdiction to grant injunctive relief.

6.4. Hearings

No rule or regulation shall be promulgated until a notice of proposed rule-making which shall contain the entire content of the proposed rule or regulation, shall have been made available for public inspection at the office of the _____ (Name of Administrative Authority), for a period of 3 business days, and if, during that period a public hearing on the proposed rule or regulation be requested by any interested person, it shall be had as soon after the close of the third business day as is practicable, provided that where a proposed rule or regulation is to be applicable to known persons only, in lieu of such posting, a copy thereof shall be sent by regular mail or delivered in person to each such person and, if hearing be waived or not, requested within 2 business days after notice would be received in the ordinary course of mail, no hearing shall be had. Any person who has requested a hearing shall not take any action inconsistent with the proposed rule or regulation pending the final determination after the hearing, which shall be 10 days subsequent to the close of the hearing, and if no such hearing shall have been made within that time, the proposed rule or regulation shall be deemed rejected.

6.5 Rules and Regulations

The _____ is hereby empowered to promulgate such rules and
(Name of Administrative Authority)
regulations in accordance with the provisions of the Code as may be required, and any rule or regulation so promulgated shall have the same force and effect as the Code, but no person shall be bound thereby until such rule or regulation has been posted in a conspicuous place at the main office of the _____, for a period of not less than 5 business
(Name of Administrative Authority)
days except that presentation to any person of a written copy of any rule or regulation shall be in lieu of the above stated posting requirement as to that person.

6.6 Granting of Licenses

a. Plumbers License: No person shall engage in the practice of plumbing either on his own behalf or on the behalf of another either as a master, journeyman, or apprentice plumber without first securing a license from the _____.
(Name of Administrative Authority)

b. Application for License: Any person desiring to secure such license shall make application therefor on forms to be prepared and provided by the Board and before a license is issued, the Board shall determine that the applicant is competent and qualified to practice plumbing on the level of the license for which he is making application and that, to the extent required by the Board, the applicant is familiar with the provisions of the Code. Any conviction for violating the Code or any rule or regulation promulgated thereunder shall be taken into consideration in determining whether or not the applicant is competent and qualified.

c. Terms of License, Transferability, Fees and Penalties:

Every license issued by the _____ shall be for a period ending
(Name of Administrative Authority)
on the thirty-first day of the December next following, and shall not be transferable. The fee for each such annual license or renewal thereof shall be $ _____ and shall be paid to the _____ before any license or renewal thereof is issued. If a
(Name of Administrative Authority)
license be not applied for on or before January 1 of each year, or within 30 days after the applicant has practiced as a competent and qualified plumber, a penalty of 10 percent of the license fee shall be imposed for each month thereafter; provided that in no case shall the penalty exceed the amount of the license fee.

d. Offenses: The practice of plumbing on each separate job by an unlicensed person shall constitute a separate offense.

e. Plumbing Business: Every person engaged in the business of plumbing shall employ only licensed plumbers in the practice thereof, except that apprentices, helpers, and laborers may be employed where all of their work is supervised by one or more licensed plumbers.

f. Provisions:

(1) License to take effect: No license shall be required under this Ordinance until the 1st day of January following the effective date of the act.

(2) Reciprocity: The Board may grant a license, without examination, upon payment of the stated fees, to a holder of a substantially equivalent license from another jurisdiction upon satisfying itself that the standards and qualifications required by the other jurisdiction are substantially equivalent to those required by it.

(3) Use of licensee's name by another: No person who has obtained a plumber's license shall allow his name to be used by another person either for the purpose of obtaining permits, or for doing business or work under the license. Every person shall notify the Board of the address of his place of business, if any, and the name under which such business is carried on and shall give immediate notice to the Board of any change in either.

g. Suspension or Revocation: The Board is empowered to suspend or revoke any license issued pursuant to the Ordinance after a hearing upon written notice containing grounds therefor, which notice shall be served personally upon the licensee or his agent at least five days prior to such hearing. At such a hearing the licensee shall be given an opportunity to present testimony, oral or written, and shall have the right of cross-examination. All testimony shall be given under oath. The Board shall have power to administer oaths, issue subpoenas, and compel the attendance of witnesses. The decision of the Board shall be based upon the evidence produced at the hearing and made part of the record thereof. A person whose license has been revoked shall not be permitted to apply for a new license within one year from date of revocation, provided, however, that the person whose license has been revoked may appeal to the courts and if the decision of the Board be reversed, license shall be reinstated. Persons whose license has been revoked and who are applying for a new license shall be re-examined and pay such fees as are prescribed in Section 6.6c.

h. Re-Examination: Any person who fails to pass an examination prescribed by the Board may apply for re-examination after the expiration of 30 days upon payment of a new fee.

i. Temporary Permit: The Board may issue a temporary license pending examination, provided the applicant holds a similar license from another jurisdiction or other reasons exist therefore which, in the discretion of the Board, merit the issuances of such a permit. Such permit shall not be valid for more than _____ days.

6.7. Inspection

Any officer or employee of the _____ may make such inspec-
(Name of Administrative Authority)
tions of plumbing installations as the _____ or member of the
(Name of Administrative Authority)
Board deems necessary or desirable. Inspections shall be at reasonable hours. Their purpose shall be to ascertain whether the Code and the rules and regulations issued thereunder are being complied with. They may be regular or special. No person shall obstruct such inspection or fail, upon request, to assist therein.

6.8. Permits for Plumbing Works

a. Issuance of Permit: Except as otherwise provided hereunder, no plumbing work in the _____ of _____ shall be undertaken unless there
(State, County, Municipality) (Name)
has been issued a permit therefor by the _____. Except as pro-
(Name of Administrative Authority)
vided in Section 6.8b, such a permit shall be issued only to a master plumber.

b. Exceptions:

(1) Single family dwellings: Any permit required by the Ordinance may be issued to a bona fide owner of a single family dwelling, which is to be occupied exclusively for living purposes, to do any work regulated by the Code on the said dwelling and any of its accessory buildings and quarters on the condition that the said owner personally purchase all material and perform all labor in connection therewith.

(2) Repairs: Repairs which involve only the working parts of a faucet or valve, the clearance of stoppages, the repairing of leaks, or the replacement of defective faucets or valves may be made without permit provided no alterations are made in the existing piping to fixtures.

c. Application for Permit: Application for a permit for plumbing work shall be made on forms prepared and provided by the _____. All applications shall
(Name of Administrative Authority)
be accompanied by the appropriate fee computed in accordance with the schedule of fees set forth in Section 6.8d.

d. Schedule of Fees: Fees for permits shall be computed as follows:

	Fee
Each plumbing fixture and waste-discharging device ------	_____
New or reconstructed sewer connection ----------	_____
Construction or reconstruction of seepage pit ----------	_____
Each septic tank ----------	_____
Each water heater ----------	_____
Each water distribution system or service connection -----	_____
Repair or alteration of any plumbing system ----------	_____
Any permit requiring inspection, minimum fee ----------	_____

e. Requirements for Plumbing Permits: No permit shall be issued until plans and specifications showing the proposed work in reasonable detail shall have been submitted to the _____ and the Board has determined from examination of such
(Name of Administrative Authority)
plans and specifications that the proposed work will conform with the provisions of the Code. If a permit be denied, written notice thereof shall be provided to the applicant who may submit such revised plans and specifications as are necessary to obtain approval. If, in the course of the work, it be found necessary to make any change from the plans and specifications on which a permit has been issued, amended plans and specifications shall be submitted and a supplementary permit shall be issued to cover the change after the same conditions required to secure the original permit have been satisfied.

6.9. Plumbers Sign

Every holder of a master plumbers license and engaged in the practice of plumbing in the _____ of _____ shall display in a conspicuous
(State, County, Municipality) (Name)
place at the entrance to his place of business a sign bearing his name and the words, "Licensed Master Plumber" in letters not less than three inches high.

6.10. Master Plumber's Bond

A person who has been issued a master plumber's license shall execute and deposit with the _____ a bond in the amount of $_____ which shall be so con-
(Name of Administrative Authority)
ditioned that all plumbing work performed by the licensee or under his supervision shall be performed in accordance with the provisions of the Code and that he will pay all fines and penalties properly imposed upon him for violation of the provisions of the Code. A master plumber's license shall not be valid unless a bond has been executed and deposited as herein provided.

6.11. Protection of Water Supply System

The Board shall make such rules and regulations in furtherance of the purposes of the Code and not inconsistent with the specific provisions of the Code, for the installation, repair, or alteration of air conditioning systems, water treatment equipment, and such other water operated devices as it may deem necessary to properly protect the water supply system.

6.12. Violations and Penalties

Any person, whether individually or as a member or employee of a partnership, or an officer, agent, or employee of a corporation, who directs or knowingly permits any violation of any of the provisions of the sections of the code, or any rule or regulation duly promulgated thereunder or who aids or assists therein, either on his own behalf or in the interests of his employer or principal shall, upon conviction thereof by a court of competent jurisdiction be guilty of a misdemeanor punishable by a fine of not more than $100 or to imprisonment in the _____ for not more than 30 days, or both for each separate violation. Each failure to comply with a mandate or prohibition of the Code shall be deemed a separate offense.

6.13. Condemned Equipment

The Administrative Authority shall condemn any used plumbing material or equipment which is so worn, damaged, defective, or constructed as to constitute a sanitary or safety hazard and such condemned material or equipment shall not be reused for plumbing purposes. Where in the opinion of the Administrative Authority condemned material or equipment should be destroyed

to prevent its reuse, he may order such destruction.

7 Operation and Effect

The provisions of the Code are supplemental to all other laws relating to plumbing which are not referred to herein and shall not be construed to modify, repeal, or in any way affect any provision of any other laws not expressly repealed herein.

8 Separability

If any clauses, sentences, paragraphs, or other parts of the Code, or the application thereof to any person or circumstances, shall, for any reason, be adjudged by a court of competent jurisdiction to be invalid, such judgment shall not affect, impair or invalidate, the remainder of the Code, and the application thereof to other persons or circumstances, but shall be confined in its operation to the clause, sentence, paragraph, or part thereof directly involved in the controversy in which the judgment shall have been rendered and to the person or circumstances involved. It is hereby declared to be the legislative intent that the Code would have been adopted had such invalid provisions not been included.

Chapter XIV

Public Sewage Disposal

General Considerations.

Public sewage disposal is a public health activity associated with engineering functions. A public sewerage system is a facility of public health engineering achievement. Although the engineer makes the plans, supervises the building and general maintenance, and acts as consultant in relation to sewerage systems, the sanitarian also has an important function in this area of sanitation, especially in relation to the smaller public sewerage systems, the semi-public systems, the industrial systems, and the private systems. The sanitarian should know how to make an inspection of a sewerage system, to detect whether the operation is satisfactory, give advice concerning the less highly technical aspects, and to know when to call an engineer for consultation. He should be able to review the plans of private systems, semi-public systems, and the smaller industrial systems, and to serve as consultant in the installation of these. Under more vigilant engineering guidance, he should be able to make inspections and act as the right hand man to the engineer in various aspects of large public sewerage systems. Thus, the sanitarian has an important role in this aspect of environmental sanitation. In order to perform effectively he must have a good knowledge concerning the functions of sewerage systems and some knowledge of the simpler engineering technology. The functions of every category of public health personnel have transitional phases where the functions of one category converge into that of the others. It is in the field of sewage disposal and water supply control that the work of the sanitarian and the public health engineer meet most intimately and require the greatest coordinated effort.

Although the history of public sewerage systems dates back into antiquity, the modern sewerage system with its sewage treatment techniques came into being about the middle of the 19th century. Boisseau, however, proposed the chemical treatment of sewage in 1762. The introduction of the water carriage system of sewage gave rise to a series of stream pollution problems which the engineer, biologist, and sanitarian are today endeavoring to solve. Where streams are large the problems tend to be less, and where the streams are small the problems tend to be great. Water supplies may become contaminated as a result of stream pollution and in some instances great epidemics have been the result. Thus the problem of the removal of fecal matter was sometimes solved at one place only to reappear elsewhere.

The United States now has a $4 billion backlog in municipal and industrial treatment plants which are needed right now but are not yet constructed.

Table 1. Index of Pollution Discharged into the Nation's Watercourses*

	1900	1920	1940	1960
Municipal Wastes	82	131	145	258
Industrial Wastes	18	137	269	517
Total	100	268	414	775

*In 1900 the pollution from municipal and industrial wastes was equivalent to the sewage discharge of 29 million persons. Using 1900 as the base year of 100 the table shows the increase in the nations's stream pollution over the past 60 years.

The U.S. Public Health Service estimates that the construction of 4,000 new sewage treatment plants and the modernization of 1,700 more are needed to handle the present load of municipal sewage dumped into the nations's river and streams. The Service further estimates that it will take $4.6 billion if municipalities are to catch up with treatment needs by 1968 -- $1.9 billion to eliminate backlog, $1.8 billion to provide for population growth, and $900 million to replace obsolete plants.

The needs for industrial waste treatment are not as well defined as the needs of municipalities. However, it has been estimated that as of 1960, more than 6,000 new projects were needed for handling waste discharges. If built now, these treatment facilities would cost about $2 billion, including in-plant changes. To wipe out the backlog of needed industrial waste treatment construction and to provide for growth, industry will have to spend between $575 and $600 million annually if it is to catch up to needs by 1968.

Table 2. Development of Sewage Treatment in United States
1860 - 1957

Year	1860	1870	1880	1890	1900	1910	1920	1930	1935	1940	1945	1957
No. Places served	10	100	200	450	950	1,600	3,000	5,100	6,800	8,516	8,917	11,131
% Population served	1.0	4.5	9.5	16.1	24.5	34.5	47.5	61.5	69.5	70.5	74.7	98.4
Places Disposing by Dilution	10	100	200	440	890	1,300	2,000	2,700		3,597	3,610	3,065
Places Disposing by Treatment	0	0	2	10	60	300	1,000	2,400		5,085	5,480	8,066

Sewage is the used or spent water supply. It is made up of 99.9% water and 0.1% solids. This 0.1% of solids is the important part of sewage. It is composed of:

a) Floating solids,

b) Fats and oils

c) Settleable solids

d) Suspended and colloidal solids,

e) Bacterial life

f) Soluble organic or inorganic material.

Up to about 1930 the bulk of sewage was disposed of by dilution, i.e., dumped untreated into some body of water. Today less than 25% of metropolitan sewage is disposed of by unmodified dilution techniques.

The methods of treatment are various, but all are based upon the separation of solids from the liquid, except where the sewage is discharged into large bodies of water after simple disinfection.

The sources of sewage are:

1) Domestic - The average amount of suspended solids in fresh municipal sewage is 0.2 pound per person per day. The ash content of feces is made up principally of sodium chloride but contains phosphates, and salts of calcium and magnesium. The organic matter of feces and urine is mostly carbon and nitrogen in various forms. Other wastes from bathrooms consist of paper, fibrous material and soap. Kitchen waste is composed of food material, soap, alkali, grease, salt, sugar, and sand. With the introduction of household garbage grinders, more and more garbage is found in the sewage. The average amount of garbage produced per person per day is around 0.55 pounds. Laundries contribute soap, dirt and starch. Household wastes may be

augmented by oil, grease, sand and dirt from garages and filling stations, from floor washings, store wastes, and cleaning establishment wastes, and by sand and dirt in periods of heavy infiltration of ground water.

2) Storm sewers - The material from this source consists of rain water and washings from streets and roofs, adding sand, gritty matter and oil. The amounts of suspended matter vary from place to place and season to season, depending on the rainfall, types of streets and snow removal. Storm sewage contains relatively little organic matter (5 to 25% of the total dry matter). Most of the material is non-putrescible and settles rapidly. Because the material settles rapidly, it may cause difficulties in sewers with flat grades, settling tanks, and digesters.

3) Industry - The character of industrial wastes depends upon the industry. Wastes from industries which are mostly cooling waters will have a low biochemical oxygen demand, while wastes from such industries as distilleries, slaughter houses, dairies, dyeing plants, tanneries, chemical plants, laundries, and the like will have high biochemical oxygen demands. When industries are concentrated in certain areas the effect of the industrial waste on the strength of sewage may be material.

The discharge into the sewers of large quantities of water used in air conditioning dilutes the sewage and probably introduces oxygen which retards putrefaction and tends to bring fresh sewage to the treatment plant. This is an aid to treatment.

Table 3 Summary of Sewer Systems and Sewage Disposal by Population, Groups and Drainage Basins, United States, 1957

Population Size Groups	Number of Communities	Estimated Population* Connected to Sewers	Type of Sewer System			Raw Sewage Disposal			Treated Sewage Disposal			Both Raw and Treated Sewage Disposal		Sewage Treatment Plants				Other	
														Primary		Secondary			
			Separate	Combined, Sanitary and Storm Sewers	Both	Number of Systems	Number of Communities	Estimated Population Served	Number of Plants	Number of Communities	Estimated Population Served	Number of Communities	Estimated Population Served	Number of Plants	Estimated Population Served	Number of Plants	Estimated Population Served	Number of Plants	Estimated Population Served
Under 500	1,254	368,086	1,032	73	7	294	319	93,109	808	930	270,617	5	4,360	317	98,728	490	175,044	1	400
500 - 1,000	1,960	1,207,421	1,565	225	24	552	563	347,625	1,322	1,390	854,135	7	5,661	550	340,973	764	506,882	8	7,346
1,000 - 5,000	5,211	9,590,763	4,164	652	143	1,527	1,536	2,736,545	3,468	3,638	6,774,414	37	79,804	1,307	2,189,222	2,126	4,533,565	35	79,860
5,000 - 10,000	1,267	7,266,284	942	199	79	315	328	1,683,245	863	926	5,507,384	13	75,655	242	1,602,816	597	3,693,534	24	237,024
10,000 - 25,000	889	11,128,680	632	148	85	210	205	2,586,930	595	672	8,321,220	12	220,530	156	1,996,612	413	5,325,713	26	1,093,695
25,000 - 50,000	299	8,044,376	178	70	44	74	65	1,970,307	199	225	5,776,939	8	297,130	71	2,159,357	110	3,205,087	18	588,825
50,000 - 100,000	134	8,446,722	67	46	20	38	30	2,081,090	94	101	6,092,632	3	273,000	25	1,524,790	62	3,978,730	12	798,912
Over 100,000	117	52,309,064	52	38	24	38	19	5,206,448	164	84	35,318,116	14	11,784,500	62	15,754,247	85	21,907,149	17	4,645,220
Major Drainage Basins																			
Northeast	888	9,740,722	523	204	79	485	439	2,037,901	392	426	6,652,070	23	1,050,751	232	4,194,970	143	1,608,326	17	1,276,575
North Atlantic	1,211	21,644,103	883	122	43	343	345	1,843,905	631	858	11,762,248	8	8,037,950	261	5,522,885	343	8,837,617	27	2,632,696
Southeast	1,108	6,495,399	1,010	3	4	349	302	2,126,435	953	789	4,071,269	17	297,695	577	1,505,099	364	2,330,605	12	328,280
Tennessee River	143	1,033,999	133	2		64	62	298,859	85	76	545,385	5	189,755	53	202,625	32	353,685		
Ohio River	1,357	9,498,465	802	385	111	626	705	3,449,790	599	635	5,282,444	17	766,231	214	1,387,718	365	3,535,356	20	611,650
Lake Erie	217	2,930,472	96	77	19	67	65	138,748	110	148	2,783,739	4	7,985	31	596,915	73	2,124,749	6	62,375
Upper Mississippi	1,548	11,917,719	1,167	271	64	233	271	1,745,238	1,156	1,274	10,164,923	3	7,558	286	977,276	863	8,315,300	7	872,745
Western Great Lakes	571	6,272,328	283	195	51	195	194	680,136	298	375	5,591,277	2	915	131	3,081,975	149	2,026,913	19	482,514
Missouri River	1,129	4,031,638	984	70	10	276	269	1,306,621	867	853	2,358,797	7	366,220	243	340,963	615	1,551,044	8	605,860
S.W. Lower Mississippi	934	5,266,403	914	5		165	166	1,829,111	799	767	3,431,292	1	6,000	240	650,906	554	2,697,559	5	84,827
Colorado River	189	740,915	182	3	1	31	29	46,561	154	159	690,054	1	4,300	63	95,523	87	549,171	4	46,860
Western Gulf	624	4,979,320	612	2		17	17	108,655	628	607	4,870,665			101	151,930	527	4,718,735		
Pacific N.W.	464	2,782,850	323	96	24	133	131	571,810	329	324	1,087,060	8	1,123,980	156	988,995	167	570,755	6	39,200
California	609	10,358,221	587	11	2	36	34	187,955	412	573	9,291,836	2	878,430	115	5,920,828	190	3,828,208	7	400,700
Great Basin	139	66,884	133	5		28	36	333,574	104	102	332,398	1	2,870	27	48,137	75	277,681	2	7,000
TOTAL	11,131	98,361,396	8,632	1,451	428	3,048	3,065	16,705,299	7,518	7,966	68,915,457	100	12,740,640	2,730	25,666,745	4,647	43,325,704	141	7,451,282

* Based on 1950 Census

From - Sewerage and Sewage Treatment - Babbitt.

* 1950 added to Table. Definition for urban is changed for 1950 census. Therefore figures are comparatively higher than for 1940.

Stream Pollution

The average amount of sewage per capita per day for the urban population of the U. S. is 100 to 120 gal. The average sewage of urban origin contains about 100,000 micro-organisms per cubic centimeter.

Our average water treatment plants (using sedimentation, coagulation, filtration, and chlorination processes) can operate successfully if the sewage does not cause river water to exceed 5000 coliform bacteria per 100 c. c. or 2000 coliform per 100 c. c. for lake water. Therefore sewage treatment must be efficient enough to bring down the counts of the contaminated waters to these figures. If only chlorination be used for water treatment, the raw water should not exceed 60 to 100 bacteria per c. c. If coagulation and pre- and post-chlorination be used besides the other processes (sedimentation and filtration), then the raw water may have a bacterial count

as high as 20,000 organisms per 100 c. c.

Classification of raw water:

1) Class A raw river water does not exceed 5000 bacteria per 100 c. c.
2) " " " lake " " " " 2000 " " " "
3) " B " river " " " " 20,000 " " " "
4) " " " lake " " " " 5,000 " " " "
5) " C " river " " exceed 20,000 " " " "
6) " " " lake " " " 5,000 " " " "

Class A indicates that the water is in good condition and no restraining measures against stream pollution are required. Class B indicates that the water is practicable for use but control measures should be maintained against excessive stream pollution. Class C indicates that restraining measures against stream pollution should be obtained.

The objectionable factors of untreated sewage disposal in streams are:

1) The scum produced on the surface of the water.
2) The sludge accumulation along the banks of streams.
3) The odors (H_2S) developed due to the limited amount of dissolved oxygen in the water.

Important factors to be considered in stream pollution are: 1) Public water supply, 2) nuisance, 3) bathing and recreation, 4) shellfish, 5) fish and natural life, 6) livestock, 7) property, 8) navigation: accumulation on river bed; effect on corrosion, 9) natural ice.

The discharge of sewage, whether treated or not, into streams, lakes, and harbors is by far the most common method of sewage disposal of urban areas throughout the world. It can be applied satisfactorily whenever the water receiving the sewage is capable of bearing the load placed upon it. When this is the case, the heavy particles settle to the bottom, the organic matter is oxidized by the oxygen dissolved in the water, and the bacteria gradually die off for lack of suitable food generally brought about by their own consumption of the available foodstuffs. The bacteria are also consumed by other organisms, killed by sunlight, or otherwise destroyed. These agencies bring about the phenomenon known as the self-purification of streams. When, however, the burden placed upon the water is too great, self-purification is protracted, water supplies may become polluted, oyster beds may become contaminated, and in severe cases, streams may be so overloaded with sewage as to become offensive to sight and smell.

Table 4. Solubility of Oxygen in Water

Temperature Degrees C.	Oxygen in p. p. m.	Temperature Degrees C.	Oxygen in p. p. m.
0	14.62	16	9.95
1	14.23	17	9.74
2	13.84	18	9.54
3	13.48	19	9.35
4	13.13	20	9.17
5	12.80	21	8.99
6	12.48	22	8.83
7	12.17	23	8.68
8	11.87	24	8.53
9	11.59	25	8.38
10	11.33	26	8.22
11	11.08	27	8.07
12	10.83	28	7.92
13	10.60	29	7.77
14	10.37	30	7.63
15	10.15		

Under an atmosphere pressure of 760 mm. of mercury, the atmosphere contains 20.9% of oyxgen. (From Sewerage and Sewage Treatment - Babbit.)

Biochemical Oxygen Demand

Water in contact with air becomes saturated with oxygen. This oxygen is termed "dissolved oxygen". The actual amount of oxygen dissolved in water will depend upon the partial pressure of oxygen in the atmosphere, upon the barometric pressure, and upon the temperature of the water. In most cases temperature is the controlling factor since the amount of oxygen dissolved varies greatly with the temperature. Thus, distilled water at 0^{o} C. and 760 m. m. pressure holds, when saturated, 14.62 p.p.m. of O_2; at 20^{o} C. it holds 9.17 parts. Without O_2 water has a flat, insipid taste.

There are many processes which go on in water that influence the dissolved O_2 content. Clean surface waters are ordinarily saturated, but in the presence of rapidly growing plant life, particularly algae, supersaturation often occurs due to liberation of O_2 by the plant cells. At the same time there is a reduction of the carbon dioxide content which is used as food for plant growth. The relation of dissolved gases to microscopic growth in water is close and important.

When water is polluted with any oxidizable material such as the extracted matter from dead vegetation, sewage, or other wastes, the O_2 content will be diminished, but may be replenished by absorption from the atmosphere if the pollution be not heavy and decomposition not too rapid. When the demand of bacterial activity for O_2 exceeds the rate at which oxygen can be dissolved from the air (practically all decomposition or putrefaction is associated with bacterial activity) the value in the water will fall and as it approaches zero, putrescible conditions arise due to anaerobic bacterial processes. This results in the production of partially oxidized compounds which possess obnoxious physical properties. In surface waters receiving sewage or industrial wastes this condition may establish a nuisance.

Dissolved O_2 is a most important determination in the study of pollution and the amount of O_2 found is an indication of the load which is being put on natural processes of purification. The amount found in the water of a running stream at different points, for instance, furnishes valuable information as to the rapidity with which self-purification is taking place below a given point of pollution. The greater the volume of the stream the greater the dilution and the less the demand on dissolved O_2. The faster the stream flows the less time it takes to reach a certain point down the stream and the greater is the demand for dissolved oxygen.

Oxygen bears an important relation to fish life. Most fish will live when the oxygen content is as low as 50 to 60% of saturation. A minimum of 5 p.p.m. of dissolved oxygen is needed in water with temperatures between 15^{o} and 26^{o}C., and 3 p.p.m. in cold winter temperatures (Moore, 1942). Below this point suffocation takes place. Therefore where sewage is dumped into streams, the character of the sewage in relation to the size of the stream should be such that utilization of the dissolved O_2 should not be great enough to reduce the dissolved O_2 content of the water below 5 p.p.m. which will allow fish life to exist. Adequate dissolved O_2 for fish life is 6.5 p.p.m.

Tne amount of dissolved O_2 required for satisfactory oxidation of organic material (such as sewage) is called the "biochemical oxygen demand" or B.O.D. This may be taken as a measure of the content of organic matter in the water. In most samples of polluted waters, the oxidation proceeds in two stages. In the first stage, lasting for 7 to 10 days or more, the carbonaceous matter is oxidized. During this stage, the rate of deoxygenation at any instant is directly proportional to the amount of organic matter present. See Fig. 1. This relation is lost when the second stage sets in, i.e., nitrification. Thus, if the daily available O_2 in a stream be 22 lbs., and the B.O.D. of sewage to be emptied into it be 125 lbs. of O_2 daily, the B.O.D. of the sewage will have to be reduced by $\frac{125 - 22}{125} \times 100 = 84\%$ in order not to cause undesirable conditions in the stream.

Dilution Factors

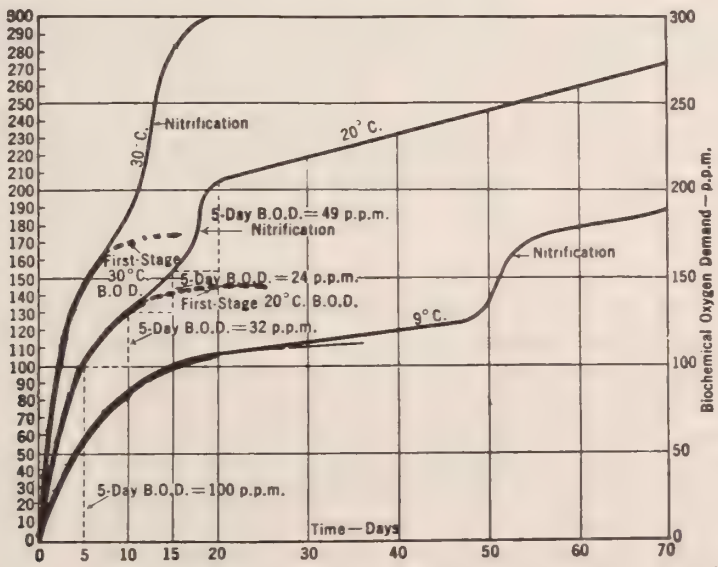
When sewage is discharged into streams the dilution must be great enough in the stream in order to prevent offensive situations. This dilution is measured in terms of the rate of flow of the stream into which the sewage is emptied, for example, cubic feet per second per capita. The factors here involved are known as "dilution factors". Dilution factors at present are arbitary since they have not been worked out with precision and, in any particular case, are limited by the uses to which the water course receiving the sewage is to be put.

The dilution factors, the percent B. O. D. reduction, and the removal of suspended solids are given for various types of treated sewage in the following table for the purpose of comparison:

Table 5 Comparison of Factors Affected by Treatment

Type of Treatment	Factors Affected by Treatment		
	% B. O. D. Reduction, 5-day, 20° C.	% Removal of Suspended Solids	Dilution Factors - cu. ft. per second* per 1000 population
No treatment or coarse screen			3.5 to 8.0
Fine screen	2 - 20	20 - 35	
Chlorination of raw or settled sewage	15 - 30		
Sedimentation	25 - 35	40 - 75	2.0 to 4.0
Rapid filtration preceded by plain sedimentation	35 - 65	50 - 80	2.0 to 3.5
Sedimentation and chemical precipitation	50 - 85	70 - 90	1.5 to 2.5
Rapid filtration preceded by chemical precipitation	50 - 90	80 - 95	1.5 to 2.5
Sedimentation and trickling filter followed by final sedimentation	70 - 90	80 - 90	0.5 to 1.0
Activated sludge - preceded and followed by plain sedimentation	80 - 97	85 - 95	0.3 to 0.8
Intermittent sand filtration	85 - 95	95 - 98	0.3 to 0.5

*1 cu. ft. per second is equivalent to 648, 000 gallons per day.



—Progressive Exertion of Biochemical Oxygen Demand at 9, 20 and 30°C. *After Theriault.*

Fig. 1. - First and Second Stages of B. O. D.

This figure shows clearly the first stage of B. O. D. in which largely carbonaceous organic matter is broken down, and, in which the B. O. D. exerted in each unit interval is a constant proportion of the B. O. D. remaining to be satisfied. The ultimate value in this stage is a measure of the decomposable matter originally present in the sample. This relation is lost when nitrification (2^d stage) sets in.

During the winter, bacterial action in the water is much more limited, and the oxygen absorption much greater than during the summer months, hence the B. O. D. of a stream during the summer is much higher. The factors upon which the degree of treatment selected for domestic or industrial waste depends upon are:

1) Rate of flow of stream into which sewage is emptied and its average summer temperature.
2) The nature of the sewage to be treated.
3) The allowable character of the effluent considered with reference to the use made of the water into which it is to be discharged.
4) The availability of suitable areas of land at proper elevation.
5) The costs of construction and operation.

Collection of Sewage

Offensive situations may be caused not only in the streams but also in the sewerage system if the quanitity of sewage to be handled and the velocity at which the sewage must be carried be not adequate to prevent deposition of solids with consequent clogging of sewers or with accumulation of deposits subject to decomposition. These factors determine the size and grade or slope of the sewers. The smallest size of sewer employed is generally 8 inches in diameter, and the grades are so chosen that the velocities of flow will be around 2 feet per second in the case of sanitary sewers and 3 feet per second for combined sanitary and storm sewers. To permit inspection and cleaning of the sewers, manholes are provided at all changes in size, grades and direction of the sewers; also at intermediate points in case of long straight runs. These structures are placed not more than 300 feet apart in the case of small sewers; their distance may be increased to 400 feet for large sewers.

Microbiology of Sewage

This is the study of the nature and activities of micro-organisms found in sewage and sewage treatment processes. The sanitarian should refer to the discussion of the growth of bacteria, the nitrogen cycle, and the self-purification of streams to refresh his memory on the basic factors involved in sewage treatment. It is important to do this because the principles involved in the processes of the digestion tank, activated sludge plant, and trickling filter also involve an understanding of the growth cycle of bacteria. The sanitarian must know that the maintenance of efficient operation of these treatment methods requires a supply of food to the bacteria at a particular constant rate and a maintenance of the environmental conditions at optimum to keep the bacteria in an actively multiplying condition (logarithmic phase). When the food supply is not adequate, the bacteria will reach the stationary phase, then gradually proceed into the decline phase. It is important to know that the activated sludge and trickling filter processes depend upon aerobic action. Such knowledge determines the methods of operation and design of the plant. Time is needed to bring the process in the digestion tank, activated sludge tank, or trickling filter back to the logarithmic phase. During this time, the efficiency of the treatment process is temporarily reduced.

Bacteria consume food for growth and for energy production. Under certain circumstances surplus energy is produced and transmitted as heat to the medium (sludge) in which the bacteria grow. Artificial composting of sludge and garbage under aerobic conditions results in rapid fermentation and heat liberation which can raise the temperature of the mass to 120^{o} - 150^{o} F. Much more of the sludge in aerobic sewage treatment processes is composed of bacteria than in the anerobic processes. Anerobic decomposition yields products which in turn can serve as sources of energy for aerobic bacteria. In the presence of large amounts of available carbohydrates, proteins are decomposed only to a limited extent. But since ammonia nitrogen is necessary for bacterial growth, wastes containing large quantities of carbohydrates, fats, and cellulose may reduce the amount of ammonia formed to the extent of limiting the growth of bacteria.

Control of bacterial environment is important especially the hydrogen -ion concentration, the temperature, and the removal of waste products. The optimum pH for digestion of sludge is usually between 6. 6 and 7. 8, but if the bacterial waste products be not removed the accumulation of acid or alkali or toxic products may reduce the efficiency of the process of digestion. It is important to maintain proper temperature control for digestion tank to attain efficient bacterial action.

Sewage microorganisms consist of nitrifying bacteria, sulfur bacteria, iron bacteria, denitrifying bacteria, sulfate reducing bacteria, coliform bacteria, algae, fungi, protozoa, and pathogenic organisms. In sewage are also found a variety of worms.

Total number of bacteria in a sample of sewage may range between 2 and 10 million per c. c. Because of the rapid growth of bacteria in sewage the actual number is of little value for analysis. But the presence of organisms in sewage is important because many methods of sewage treatment depend on biologic action for their results. Bacteria can consume only liquid food in their process of growth and development. They produce enzymes to dissolve the organic solids. The decomposition of sewage depends to a large extent on this action of bacteria.

The first stage of sewage decomposition is marked by the rapid disappearance of the available oxygen (aerobic action). The second stage is putrefaction (anerobic). Third stage is nitrification and stabilization of the products of putrefactive decomposition.

Composition of Sewage Solids

If sewage be evaporated, the residue of solid material is composed of:

1) Dissolved solids - These consist of all readily soluble substances, salts from the water supply, soluble material in urine, meat and vegetable extracts, acids and alkalies from industries, etc. Much of the soluble solids passes thru treatment devices unchanged, while some must be oxidized or stablilized to relieve the load on the receiving stream.

2) Suspended solids - These include all floating material and are usually equal to about 1/4 of the total of solids, but may be considerably more in strong sewage. A part of the suspended solids can be volatilized by burning, but about 1/5 to 1/3 is inert, non-volatile mineral matter. The total suspended matter can be divided into two portions:

a) Settleable solids - This part settles readily upon standing. Fresh sewage will have more setteable solids than stale sewage since disintegration and decomposition is greater in the latter. The breaking-up effect of pumping may reduce the amount of setteable solids. Trade wastes of an alkaline reaction will tend to disperse fine particles and increase the amount of setteable solids.

b) Non-setteable suspended solids - This consists of finely divided suspended material in the form of pseudocolloidal and true colloidal particles. About 1/2 of the suspended solids are non-setteable.

Dissolved and suspended solids are composed of both volatile and fixed materials, i. e., materials, which are lost as vapor on heating and materials which are not lost.

Physical Characterization

Normal fresh sewage is gray. Black or dark color may indicate stale or septic sewage. Other colors may be due to different types of industrial wastes.

Normal fresh sewage is almost odorless. Putrid odors as those of H_2S, indol, skatol, etc., indicate stale sewage. Certain industrial wastes give particular odors.

The normal temperature of sewage is slightly above that of the water supply because of the heat added during the utilization of the water. Temperature varies with season, types of trade wastes, and presence of ground or surface water.

Many of the determinations commonly included in sewage analysis are the same or similar to those of water analysis. Most of the tests give indirect or inferential information as to the properties of the sewage and it becomes necessary to interpret the analysis as a whole rather than drawing information from separate tests. The choice of tests depends upon the information desired. In general, sewage is analysed for the purpose of predicting or determining its effect upon water courses into which it may be discharged, or for predicting the required degree of treatment, or determining the efficiency of the treatment process. Besides the tests for sewage or effuent given in the following table, other tests may be desired applying to bacteria, plankton, hydrogen sulphide, carbon dioxide, hardness, and iron.

Table 6 Typical Sanitary Chemical Analysis of Sewage,
Parts per Million Except as Noted

Constituent	Strong		Medium		Weak	
Solids, total	1,000	(1230*)	500	(720*)	200	(430*)
Volatile	700	(810*)	350	(420*)	120	(240*)
Fixed	300	(420*)	150	(300*)	80	(190*)
Suspended, Total	500		300		100	
Volatile	400	(220*)	250	(133*)	70	
Fixed	100		50		30	
Dissolved, Total	500		200		100	
Volatile	300		100		50	
Fixed	200		100		50	
Settleable (ml-per liter)	6.4		3.8		2.1	
B. O. D., 5 day, 20°C.	300	(413*)	200		100	
Oxygen consumed	150		75		30	
Dissolved oxygen	0		0		0	
Nitrogen, Total	86	(40*)	50	(28*)	25	(13*)
Organic	35		20		10	
Free ammonia	50	(22*)	30	(12*)	15	(4.2*)
Nitrites (NO_2)	0.10		0.05		0.00	
Nitrates (NO_3)	0.40		0.20		0.10	
pH	7.1		7.4		6.9	
Chlorides	175	(79*)	100	(38*)	15	
Alkalinity	200	(18*)	100	(40*)	50	(31*)
Fats	40		20		0	(6*)

From Sewerage and Sewage Treatment - Babbit
*Figures supplied from Principles of Sewage Treatment - Rudolfs

Sewage Treatment

The history of sewage disposal from ancient times to the present describes a trend of acceleration and concentration of natural processes on a smaller and smaller unit of land per unit of population, from surface and broad irrigation to the activated sludge and high-capacity trickling filters.

The fundamental processes in sewage treatment are:

1) Separation of suspended matter from the liquid sewage.

2) Destruction of the putrescible organic matter in the liquid sewage and final mineralization by the processes of bacterial action and oxidation.

3) Transformation of the sewage sludge to condition of stability and inertness by bacterial action.

4) Destruction or removal of the bacteria from the liquid effluent.

Methods of Sewage Treatment

Dilution. Disposal of untreated or partly treated sewage under conditions which produce no serious menace to health or are non-offensive, can be practiced only by communities located on relatively large bodies of water.

For the dilution method to be effective, the diluting water must:

1) Have a high oxygen content.

2) Contain proper aquatic life to bring about self-purification.

3) Have sufficient current to allow thorough mixing to carry away the diluted sewage.

Besides these conditions, the sewage must be fresh, containing no rapidly settling or putrefying solids or otherwise floating material.

Irrigation. The two methods of irrigation generally used are surface and sub-surface. Sub-surface irrigation is used mainly for single or groups of houses. Surface irrigation is used mainly in the United States in areas with sandy soil and low rainfall, and is still a commonly practiced method in Europe. There are four methods used in applying sewage to the surface, namely, spraying, intermittent flooding of surface with several inches of sewage, furrow irrigation between rows of crops or trees, and border irrigation where land is divided into strips. Raising vegetables on sewage farms is considered objectionable.

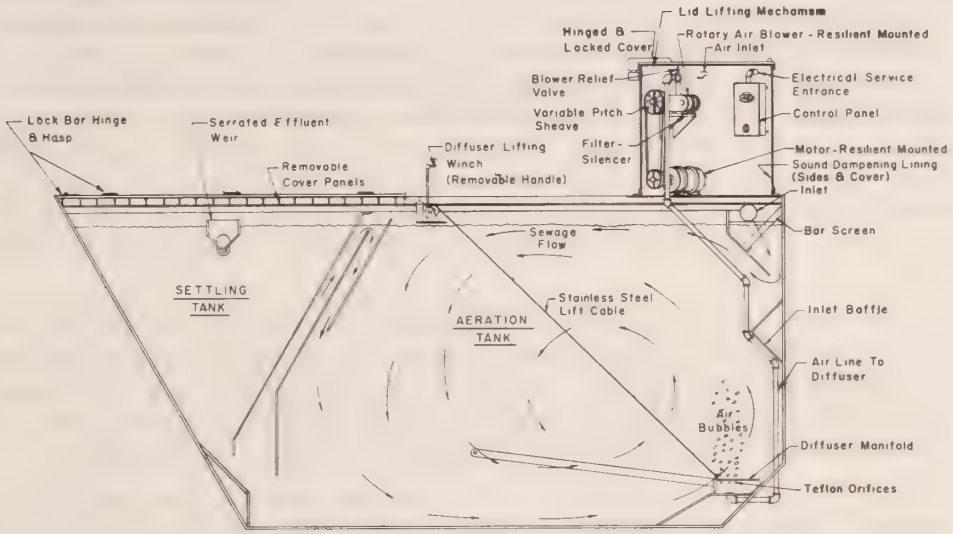


Fig. 2

Aerobic Digestion Plant - Diagrammatic Cross-section

"Oxigest" - Smith & Loveless

Waste Stabilization Ponds: Oxidation Ponds or Sewage Lagoons

In last ten years, many articles have been written which indicate that the sewage lagoons may be more efficient and of wider applicability than heretofore believed. This may be very important to the town or subdivision that has land available and desires a low cost method of treatment.

These ponds have been used in the northern plains States for complete treatment of raw sewage, but in the southwest they are mainly used for secondary treatment. Our knowledge has been mostly obtained from operating results and only since 1950 have we had laboratory determinations of the details of the process. We still need much research to determine accurately the most efficient design.

Lagoons or oxidation ponds are now described as waste stabilization ponds since this more accurately describes the function of the pond. The activity in the lagoon is described as a complex symbiosis of bacteria and algae. The principal work of treatment is accomplished by aerobic bacteria which oxidize the organic carbon in the sewage to carbon dioxide. The algae, in the presence of light, utilize the carbon dioxide to make algal cells and release oxygen in the process. The oxygen is utilized by the bacteria.

The pond effluent, due to the large number of algal cells, may contain as much organic material as the sewage influent. Whereas the entering sewage solids are highly putrescible and hazardous to public health, the algal cells in the effluent are highly stable and have no pathogenic significance. The algae constitute a living food which may be of much value in promoting the growth of fish and other wildlife.

The B. O. D. test may not reflect the actual efficiency of an oxidation pond in stabilizing the organic material in sewage. If the lagoon effluent samples for the B. O. D. test contain large numbers of living algae which die during the five day incubation period, they will create an oxygen demand that does not actually exist.

The reports of the North Dakota and South Dakota State Health Departments indicate that the performance of lagoons with a light B.O.D. loading have a warm weather removal of 98% or better. Other areas with high B.O.D.'s remove from 60% to 90% of the B.O.D. It is stated in many of these reports that the lower results are believed due to decomposing algae in the B.O.D. test. Properly designed lagoons will give B.O.D. removals and coliform count reductions comparable to the conventional type of sewage plants.

The effect of the algal cells on the receiving stream is largely determined by the stream. Whether the cells remain young, become old, or die will be determined by the new environment. If the stream at the place of discharge be polluted, the new environment should be a favorable one, and the algae should be beneficial in producing a surplus of oxygen, which will assist in minimizing the oxygen sag. Farther down the stream, where after recovery the waters are clean and contain much dissolved oxygen, the environment becomes unfavorable; algal respiration may exceed algal oxygen production resulting in a small oxygen demand. Thus the algae are beneficial where conditions are critical and oxygen is scarce, and will create an oxygen demand only when such demand has no significant deleterious effect. Similarly, death of the algae and an exertion of B.O.D. by the dead cells should not occur to any significant extent except in very clean streams.

The algae are rich in protein and consideration is being given to its utilization in animal feeds. It is evident, therefore, that sewage may have important possibilities as a low cost nutrient for industrialized photosynthesis. Assuming that algal cells can be economically separated from the liquid, the growing of algae in sewage would provide adequate sewage treatment while reclaiming a large part of the organic material contained in such a waste.

In all studies it has been consistently observed that natural sewages with higher 5-day B.O.D. values support greater populations of algae than lower strength sewages, such as primary effluent.

Odors and nuisances are no problem or are less of a problem than a conventional treatment plant. A well planned and well maintained lagoon to all appearances looks like a very pleasant body of water. The observer can walk around the dikes without noticing any nuisance condition, and certainly would not recognize the area as being fed by raw sewage. Although mosquito breeding is not expected in ponds which are well designed and maintained, top water minnows (Gambusia) might be introduced to provide an additional margin of safety for the destruction of mosquito larvae. It has been reported that various types of fish have been introduced into and thrive in several existing ponds.

Most of the experience in this country has been with aerobic lagoons. There are indications that smaller anaerobic lagoons with short retention times may be more effective than aerobic lagoons. More experience and knowledge must be gained in order to be able to make recommendations with less caution for the use of anaerobic lagoons. However, anaerobic ponds have been found satisfactory for packing house wastes. It was found that an anaerobic lagoon for removing up to 70% of the B.O.D. loading, followed by an aerobic lagoon to remove most of the remainder, could be satisfactory and economical if special attention be given to the anaerobic phase to prevent malfunction. A two stage oxidation pond system consists of a small anaerobic pond which receives the raw sewage and one or more aerobic ponds following in series. From the standpoint of removing organic matter and producing a stabilized final effluent, this type of system appears to work well.

The reduction in coliform counts in some of the lagoons has been very good, better than 99% being reported from several installations. In one lagoon used for secondary treatment the average plate count of the salmonella-Shigella group was 400 per ml., in the influent and zero in the effluent.

Although shallow lagoons of 1 to 2 feet in depth work best from the standpoint of most efficient utilization of sunlight in photosynthesis, there are practical reasons for depths of from 3 to 5 feet. The most important reason is that water less than 3 feet in depth tends to become choked with water weeds and plants. Depths of three feet or more also give space for accumulation of sludge and serve to dilute the raw sewage more than would shallower depths. The banks of the lagoon should be compacted and watertight and provided with a fence to keep out cattle. The grass and weeds on the banks should be cut so as to allow the wind to disturb the surface as much as possible, thereby providing some aeration. The inlet should be in the center

of the lagoon so that the sewage will be quickly mixed with the pond water, and the sludge will be more evenly distributed over a larger part of the bottom of the lagoon. The depth should be 3 feet to 5 feet with 3 feet of free board.

An average value for determining lagoon size would appear to be about 2.5 acres per 1000 people. This figure has been widely used successfully.

A design of one acre per 1,000 people with one quarter of the area being an anaerobic pond and three quarters of the area being an aerobic pond seems to be a practical and economical method for treating raw sewage. In the southern half of the United States a design of 1.0 acre per 1,000 people would seem to be adequate. For the northern part of the country with severe winters a higher figure would be necessary, probably 3.0 acres per 1,000 people. For a city of 50,000 people in a mild climate this would mean 50 acres of lagoons and perhaps 80 to 100 acres of land.

Design: The oxidation pond must be engineered to be effective. Certain informal design criteria for oxidation ponds are as follows:

1. Ponds should be as regular in shape as possible.

2. One acre of pond area must be provided per 200 people, which is a loading of about 35 pounds of B.O.D. per acre. (Note that this is pond area and does not include levees.) If the pond is to serve a subdivision that is to have garbage grinders as integral fixtures in homes, the 200 persons per acre is not applicable and a special evaluation of loading will be required.

3. The outlet control structure should be designed so that the water level in the pond can be varied to provide from 2-1/2 to 5 feet of depth depending on the season or special conditions which may be of influence. The purpose of a design to provide changes in pond depths is twofold: a) to enable the control of mosquito breeding by controlling weed growth along the edge of the pond; and b) to be able to maintain a relatively uniform temperature by having a greater body of water due to the increased depth in the summer months, yet being able to decrease the depth for maximum treatment in the winter months.

4. The levees should be constructed so as to minimize erosion and in such a manner that weed growth can be controlled over the surfaces, particularly at the water line.

5. The pond should be enclosed by a good fence to keep out cattle and the area should be posted to keep people from using it as a recreation area either by intent or accident.

Maintenance and Operation: The cost and effort required for the satisfactory maintenance of oxidation ponds is less than that required for any other treatment process. However, regular and proper maintenance of these units is very important for continuously satisfactory operation. The maintenance tasks required can be facilitated by thoughtful design.

1. The most important part of the ponds are the levees or dykes and accordingly their maintenance is also important. Proper maintenance includes:

a. Early sodding of levees with suitable persistant grasses to reduce erosion hazard with resultant wash into the pond.

b. Regular mowing of grass on the levees to prevent the growth of weeds and other deep rooted plants, not only to prevent erosion, but to prevent vegetation growing or hanging into the pond water, facilitating mosquito breeding.

c. Maintaining fences and keeping gates closed to prevent livestock damage.

d. Repair of erosion, settling, or rodent damage to levees. Control burrowing rodents if difficulty be encountered.

e. Maintaining access roads to facilitate maintenance activities. In addition to the above, the following general maintenance procedures should be observed:

2. With the onset of warm weather in late winter or early spring, pond water level should be raised to maximum operating depth of 5 feet by appropriate adjustment of the overflow control mechanism.

3. Pond water depth may be lowered at the onset of cool weather in the fall, to the lower operating depth.

4. Gears, valves, levers, and other critical parts of the overflow control and inlet and outlet system should be regularly serviced and lubricated as required.

5. Although no difficulty with odious benthic (blue green) algae is normally experienced in oxidation ponds, some difficulty has been encountered in new ponds, and in some cases in old ponds where low water levels have resulted in high water temperatures. When such difficulty is encountered, relief can be obtained by running an outboard motor boat through the algae surface mats which will break them up and allow the dead algae to sink. Motor boat operation should be kept to a minimum to prevent damage to the levees.

6. Ponds should be stocked with Gambusia affinis (top water minnows) as soon as appreciable water has accumulated in a new pond. This will help prevent mosquito breeding therein. Stocking of ponds with game fish is discouraged to prevent unnecessary access to pond, and to avoid nuisances arising from decay of dead fish killed by intermittent oxygen depletion and plankton poisoning.

Screens. Coarse screens have openingsmore than 1/4" in width and collect at most a few percent of total suspended solids. Fine screens have openings less than 1/4" in width. Fine screens have openings less than 1/4" in width. Fine screens are used:

1) As partial treatment followed by chlorination.
2) At some activated sludge plants where no sedimentation is provided.
3) Where it is necessary to relieve the load on various units.
4) Where certain types of trade wastes are present in sewage.
5) Where unusual conditions prevail.

Fine screens remove about 8 to 15% of suspended matter, and are self-cleaning. The efficiency of fine screens is enhanced by placing a mat of coke breeze, fine coal, slag, coarse sand, or paper pulp on top of them. By this method about 20 to 35% of the suspended solids may be removed. Such screenings are disposed of by burying in shallow trenches, allowing aerobic decomposition (lime should be added to prevent acidification of soil); by de-watering in presses and centrifuges followed by incineration; or by digestion, usually with sludge. To prevent nuisances and to overcome objections to handling screening, grinders may be employed to cut or shread the screening into pulp so it can be returned to the sewage. To overcome the objectionable features of collecting, conveying and disposing of screenings, a comminutor may be placed in the sewage flow channel to cut up the floating material as it passes through the machine.

The advantages of grinders and comminutors are:

1) There are no unsightly or objectionable conditions in handling the screenings.
2) The shredded material settles well and can be handled with the sludge.
3) The shredded materials can be digested readily.
4) The shredded materials do not clog pumps or pipes.

The disadvantages are:

1) The increase of the load on treatment tanks.
2) The tendency to produce scum trouble in sedimentation tanks.
3) The tendency to produce scum trouble and accelerate foaming in Imhoff tanks.

Ground garbage in sewage influences the sewage treatment processes as follows:

1) Increases formation of scum.
2) Increases quantity of sludge.
3) Increases the B.O.D. of settling tank effluents.
4) Requires submergency by stirring or mixing in the digestion units.
5) Produces more gas than primary or activated sludge and requires more careful reaction control.

Grit Chambers, Detritors, and Skimming Devices. Grit chambers and detritors are used to remove readily setteable inorganic matter which can be separated easily from sewage.

Skimming devices are used to remove oil, grease and scum.

Grit chambers are usually long, rectangular chambers two or more in number, designed to maintain a velocity of 1 to 1 1/2 feet per second, the former velocity being standard. The retention time should be 60 to 90 seconds. The capacity of a grit chamber is directly proportional to the surface area, regardless of the relation of width, depth and velocity. Grit is removed by hand in small plants and mechanically in large plants. The quantity of volatile matter in grit may vary from 1 to 60%.

Detritors and Grit Collectors. These units are used for collecting and washing grit. The mechanism for removing the grit may consist of plows mounted on radial revolving arms, moving rakes, scrapers, endless belt conveyors, which move against the current allowing the organic matter to be washed out. The washed grit contains no more than 3 to 5% putrescible matter. Grit is disposed of by mixing with the soil, resurfacing roads, or land filling.

Skimming Devices are used for pre-treatment of sewage containing considerable quantities of oil, grease, soap and fat. The separation of these materials is greatly aided by 3 to 15 minute periods of aeration whereby particles of grease and oil adhere to air bubbles and are carried to the surface. Small quantities of acid or chlorine speed up the separation. Scum is removed by hand in small plants but mechanically in larger plants, by such devices as surface arms and water jets. The scum is buried, digested or burned.

Sedimentation. Suspended solids capable of settling within a reasonable time, thus allowing the sewage to remain fresh, are removed in sedimentation tanks. The principal factors influencing sedimentation are:

1) Size of particles: The greater the size the more rapid is the rate of settling. Particles larger than 1 mm. in diameter settle readily; between 0.1 and 1 mm., remain suspended a long time; less than 0.1 mm., remain suspended.

2) Specific gravity of particles: When compact the particles settle more readily than when fluffy.

3) Concentration of suspended matters: The higher the concentration the more efficient the removal of suspended matter.

4) Temperature: The higher the temperature the lower the viscosity of the liquid, and the more rapid is the rate of sedimentation. This increased rate of sedimentation is especially true as the temperature rises from 40° to 85°F. Higher temperatures appear to interfere with settling.

5) Period of retention: The longer the period, within limits, the higher is the efficiency of sedimentation. An average detention period of 2 hours is the most economical. Primary settling tanks without mechanical cleaning devices may require longer detention period.

6) Depth, shape, baffling, and operation of basin.

7) Velocity and length of flow through the basin.

8) Wind blowing on the surface of the water.

9) Biological, electrical, chemical and other effect.

The efficiency of settling tanks varies from 45 to 70% for suspended solids. from 85 to 99% for settleable solids removable, and from 25 to 40% for B.O.D. reduction. (Fig. 8)

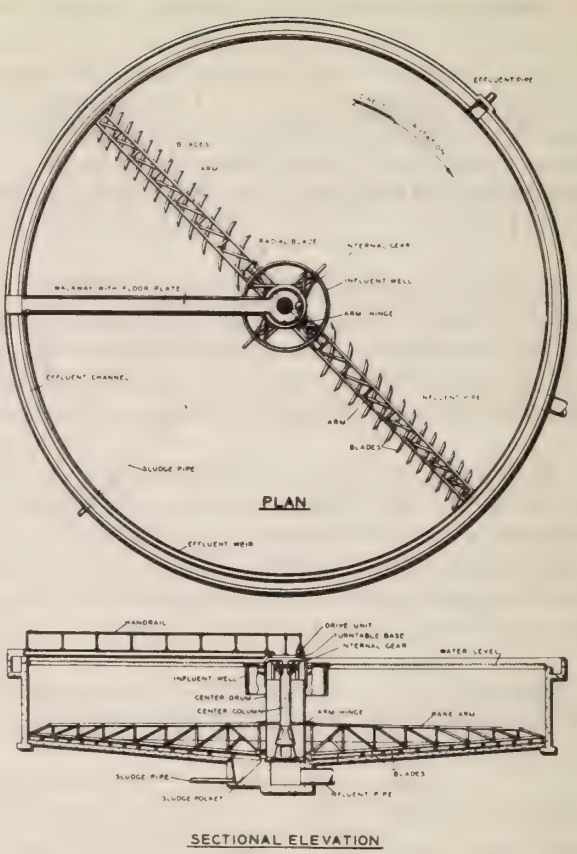
Tanks may be square or round for vertical flow and rectangular for horizontal flow. They may have mechanical or manual methods of sludge removal. Manual and some types of mechanical sludge removal require a gently sloping bottom and a sump into which the sludge can be pushed. Mechanical sludge removal is accomplished by scrapers, ploughs or suction devices. Figs. 3, 4. The Imhoff tank serves both as settling tank and digestion tank - the upper story

for settling and the lower for digestion. (Fig. 14) The "clarigestor" promoted by the Dorr Co. consists of a circular clarifier with mechanical sludge removal into a circular sludge digestor placed underneath the clarifier and can be considered as a more advanced type of Imhoff tank. (Fig. 14) These are of two types, namely, horizontal and radial flow tanks. The settleable materials slide down the inclosed sides and pass into the digestion chamber, but the rising gas bubbles and sludge particles cannot escape into the settling compartment.

Flocculation. Gentle stirring and short periods of aeration of sewage bring suspended particles together into small flocs; this results in better settling. Mechanical stirring with chemicals for 15 to 80 minutes increases the removal of suspended solids from 10 to 30% and a corresponding B.O.D. reduction. The addition of inert materials such as clay, paper pulp, etc., to aid floc formation is generally not economical.

Chemical Treatment[1]

This process can be used in conjunction with oxidation devices to prevent overloading, and to reduce the required capacity especially where industrial wastes which are toxic to bacteria are present in sewage. The process consists of the removal of non-settleable solids by the use of a coagulating chemical which causes fine particles to form a floc and settle out. Dissolved organic matter is not greatly affected.



From Dorr Catalog
Fig. 3 Circular Sedimentation Tank With Rotary Sludge Collector

Chemicals are added to sewage by dry or solution feed in proportion to requirements based on trials and performance at the plant. They are mixed with sewage by a flash mixer for 1 minute or less, followed by slow agitation for 20 to 30 minutes in flocculator. The coagulated sewage passes to a clarifer in which the floc settles, leaving a clear supernatant fluid which may be chlorinated and discharged. Pre-settling before chemical treatment has no advantage for average sewages. The return of chemically coagulated sludge to the primary settling tanks to produce greater clarification and denser sludge has little value except when sewage is very weak or when industrial wastes are treated. With economical dosage, an effluent can be produced containing 50 p.p.m. suspended solids, and with higher coagulant dosages, as much as 90% suspended solids and 70% B.O.D. can be removed. This type of treatment is particularly effective in preventing pooling in overloaded trickling filters, in increasing the capacity of sand filters, and in pretreating sewage containing large quantities of oxidizable waste.

Theory of Coagulation.[2] Since the coagulation process is concerned primarily with the separation of non-settleable suspended materials, the theory relating to the process deals with the

1. Biochemical treatment of sewage and industrial wastes by enzymes have been experimented with. These biologically active additives are supposed to maintain normal digestive activity in municipal or industrial sewage disposal plants, domestic septic tanks, or industrial grease traps.
2. Chemical Treatment of Sewage and Industrial Wastes, National Lime Association, by Dr. William A. Parsons.

behavior of finely divided particulate matter. In scientific language, non-settleable suspended materials are termed "dispersions". Materials comprising "dispersions" in sewage and wastes may range in size from 0.1 mμ to 100 μ. [3] Since dispersed materials ranging in size from about 1 mμ to 1 μ are termed colloids by chemists and physicists, it follows that non-settleable suspended materials present in waste water exhibit the properties of colloids. A general understanding of the behavioral characteristics of colloidal systems is essential for an informed grasp of the principles of coagulation.

The most significant property of colloids is small size which is responsible for establishment of conditions favorable for creation and maintenance of dispersions. The most important stabilizing factors associated with colloidal dispersions are electrostatic repulsion and hydration. Both of these factors are surface phenomena which become important due to the large surface area offered by small particles. For instance, if a cubic centimeter possessing a surface area of 6 square centimeters were subdivided into colloidal-sized cubes of 10 mμ on a side, the surface area would total 6 million square centimeters. With surfaces of this magnitude, it is not surprising that factors relating to surface chemistry and surface physics are paramount in the behavior of colloidal systems.

When the surface of a colloid has a strong affinity for water, it is classed as hydrophilic. Such particles tend to acquire a film of water molecules held by the surface. The film of water increases the stability of the dispersion presumably by shielding the particle from the action of coagulants and from contact with other particles. Colloids with surfaces possessing a weak affinity for water are termed hydrophobic. Hydrophobic dispersions may be stabilized indirectly by hydration if a substance be present which has an affinity for both the surface of the particle and water. The particles of such systems are considered to be coated with a film of the intermediate substance, which in turn attracts a film of water molecules. Such systems are described as protective colloids, and the intermediary substance is the protecting agent.

The principal stabilizing factor for most hydrophobic colloidal systems is electrostatic force. The surface of colloidal particles has a tendency to acquire an electrical charge as a result of ionization of surface components or preferential adsorption of ions from solution. In aqueous systems, hydrogen and hydroxyl ions are invariably present even in the absence of other ionized solutes. Differences in properties of various ions will result in preferential adsorption on the surfaces of colloids with the result that all particles of similar composition acquire a charge of the same sign as the preferentially adsorbed ion. The electrostatic repulsion between charged particles stabilizes the dispersion by decreasing the probability of collisions which could effect aggregation of particles into clumps of settleable size.

The influence of electrical charge on the stability of dispersed systems is a function of the "Zeta potential," which is the magnitude of the charge at the boundary between the volume held by the particle and the solution. The term "volume held" is employed to describe the particle plus the volume occupied by the envelope of ions and water molecules that for simplicity may be considered to remain within the possession of the particle. The outer regions of the envelope may be visualized as loosely held and capable of deformation. The boundary between the envelope and the solution serves as the shear layer when the particle undergoes movement relative to the solution. The magnitude of the zeta potential may be estimated from electrophoretic measurement of particle mobility, that is, the mobility of the particle in an electric field. The stability of colloidal dispersions decreases as the zeta potential of component particles approaches as value of zero. Extensive application of zeta potential determinations has been advocated for the development and operation of coagulation processes.

Factors tending to destabilize colloids are gravitational forces, Van der Waals forces and Brownian movement. Due to the small mass involved in colloidal systems, gravitational force is usually relatively small compared to other forces affecting the system. Van der Waals forces are attractive forces between particles that may be envisioned as molecular cohesive

3. mμ = millimicron = 3.94×10^{-8} inches.

forces. Such forces may increase in magnitude at a rate thousands of times that of electrostatic forces as particles converge. Thus, although Van der Waals forces are negligible when masses are even slightly separated, they may become dominant if physical contact is induced.

Brownian movement is the random motion imparted to colloid particles as a result of impact with molecules of the suspending medium. The kinetic energy of the molecules increases with increased temperature, which effects an increase in the intensity of Brownian movement. The phenomenon exerts a destabilizing effect on dispersions because if collisions be effected, aggregation may result.

The aggregation of dispersed particles is induced by addition of chemical coagulants to decrease the effects of the stabilizing factors, hydration and zeta potential, and by agitation of the medium to encourage collisions between particles. Unfortunately, gross chemical dosages are normally required to materially affect the degree of hydration of colloids; therefore, hydrophilic dispersions may be difficult to treat economically by coagulation. Dispersions stabilized principally by electrostatic force are in general amendable to coagulation inasmuch as addition of small doses of suitable electrolytes (coagulants) may effect significant change in the zeta potential of the particles. It is important that coagulants contribute polyvalent ions of charge opposite to the zeta potential of the dispersion. On a molar basis, bivalent ions seem to be about 10 to 50 times and trivalent ions about 300 to 700 times as effective as monovalent ions for destabilization of dispersions in waste water. Since most dispersions encountered in wastes are stabilized by negative charges, coagulants commonly contribute polyvalent cations such as aluminum, ferric, ferrous or calcium. Organic polyelectrolytes are also effective coagulants.

The reactions that occur following addition of polyvalent metal ions to waste waters are not fully understood. Ferric or aluminum ions added to waste water are rapidly distributed throughout the medium by a flash mix. These ions are active as evidenced by their ability to participate in the following reactions under favorable conditions:

1. The ions may react with constituents in solution such as hydroxides, carbonates, phosphates, sulfides or organic matter to form complex gelatinous precipitates of colloidal dimensions that are termed microflocs. Upon standing, the dominant composition of such precipitates is frequently a hydrous metal oxide. The microflocs may possess a positive charge, or zeta potential, depending upon reaction conditions and factors such as composition of precipitate, pH, and coagulant dosage. Low pH normally favors the acquisition of a positive charge. If a positive charge exists on the microflocs and the particles of the dispersion have a negative charge, aggregation of the microflocs and the dispersed particles of the waste will be induced by electrostatic attraction. If the microflocs possess a neutral or a slightly negative zeta potential, aggregation can still be induced through collisions. Some evidence suggests that aggregation of microflocs with dispersed waste constituents is the paramount mechanism effecting coagulation in water treatment.

2. Highly charged ions may penetrate the film of ions and water surrounding the negatively charged particles of the dispersion which will partially neutralize the zeta potential, possibly to the point of inducing coagulation. This mechanism is probably of secondary importance in the coagulation of most wastes.

3. An increase in the concentration of cations in solution interferes with the transmission of electronegative forces of repulsion that stabilize dispersions with a negative charge. If the cations be polyvalent, the interference is more pronounced. Hence, the addition of polyvalent ions shrinks both the force field and the envelope boundary which serve to protect the particles from collisions. If ion exchange occurs between monovalent ions on the surface of the particles and polyvalent coagulant ions, destabilization of the dispersion is induced.

During the flocculation process involving gentle agitation, conditions are maintained to afford continued aggregation of the destabilized mixture of microflocs and waste constituents. The agitation is controlled so as to provide velocity gradients that will not disrupt flocs of settleable size, yet will offer a high probability of collisions between suspended particles.

In this stage of the process, continued purification may be envisioned through mechanical entrapment of suspended matter during floc aggregation and by continued adsorption on the great surface area provided by the floc.

Auxiliary Factors

In addition to the aforementioned mechanisms, other factors may contribute to coagulation and in certain situations may become important features of the process. One such factor is pH. The level of pH may affect the magnitude and sign of the charges on both the dispersed waste material and on the microflocs of precipitated coagulant material if hydrogen or hydroxyl ions be involved in surface ionization or preferential absorption. In addition, the solubilities of precipitated coagulant material are usually a function of pH. Coagulation processes are generally conceived to operate within a range of pH values in which the solubility of the floc is low. For some processes, the optimum range of pH is narrow, for others it is comparatively wide, and for some there are more than one effective range. If adjustment of pH be required during coagulation, the results effected and the properties of the floc may differ appreciably depending on the chemical composition of the agent employed for pH control. The role of the anion as well as the cation is important in coagulant chemicals. Experimentation with the particular waste in question is the only reliable means for evaluation of the type of anion, monovalent or divalent, which the coagulant chemical should have for superior action.

A great deal of interest has developed concerning "coagulant aids". Coagulant aid is a term applied to agents that are used in addition to conventional coagulant chemicals to assist in the destabilization, flocculation, or sedimentation phases of the coagulation process. Common agents are organic polyelectrolytes, activated silica, clays, or pulverized limestone.

Polyelectrolyte coagulant aids consist of synthetic compounds with a very high molecular weight in the range from 10^5 to 10^6. The compounds are produced by joining a large number of recurring units of small molecular weight so as to form a molecule of colloidal size. Each recurring unit comprising the polymer will contain one or more ionizable radicals; consequently, it is possible to classify the polymers in accord to their charge in the ionized form.

Anionic polyelectrolytes are negatively charged upon ionization as typified by polyacrylamides or polycarboxylic acids. Activated silica, consisting of cross-linked chains of polymerized silicic acid, may also be classed with this group. These polyvalent ions may be powerful coagulants for dispersions stabilized by positive charges. In addition, anionic polyelectrolytes are employed for improvement of the properties of flocs formed by addition of aluminum or iron salts. The polymer ions are believed to provide charged nuclei inducing aggregation of microflocs. The ions may also serve as binders for the floccule. The desired result is a tough floc, resistant to attrition and easily dewatered.

Cationic polyelectrolytes as typified by polyamines are positively charged upon ionization. Among this group are the most effective known coagulants for dispersions stabilized by negative charges. Polymers may be employed in waste treatment practice to supplement metallic salt coagulants or they may be used exclusively.

Coagulant aids such as clays, Fuller's earth, or pulverized limestone may be employed as nuclei for floc formation or as weighing agents to improve floc settleability. The use of these materials is generally restricted to special situations.

The advent of numerous polyelectrolyte "coagulant aids" in recent years has expanded the potential of coagulation processes in regard to efficiency and flexibility. The application of coagulant aids can (1) decrease the time required for floc formation, (2) increase the size, density, and toughness of the flocs, (3) extend the effective range of coagulant dosage, (4) extend the effective range of pH and (5) separate waste constituents heretofore passed. The availability of these new coagulants has also renewed interest in the measurement of the "zeta potential" as a control parameter for coagulation.

Table 7. Characteristics of Coagulants

Coagulant			Theoretical Precipitate	
Name	Usual Commercial Formula	Composition	Solubility Product 18° C.	Usual pH Level of Application
Alum	$Al_2(SO_4)_3 \cdot 14\ H_2O$	$Al(OH)_3$	1.3×10^{-33}	4.5 - 7.0
Copperas	$FeSO_4 \cdot 7\ H_2O$	$Fe(OH)_2$	1.64×10^{-14}	8.5 - 10.5
Chlorinated Copperas	$Fe_2(SO_4)_3 \cdot FeCl_3$	$Fe(OH)_3$	1.1×10^{-36}	4-6 & 8-10
Ferric Chloride	$FeCl_3$	$Fe(OH)_3$	1.1×10^{-36}	4-6 & 8-10
Ferric Sulfate	$Fe_2(SO_4)_3 \cdot 2\ H_2O$	$Fe(OH)_3$	1.1×10^{-36}	4-6 & 8-10
Lime	$Ca(OH)_2$	$CaCO_3$	9.5×10^{-9}	9- 11.5
		$Ca_3(PO_4)_2$	3.8×10^{-29}	10 - 11
		$CaSO_4 \cdot 2H_2O$	2.1×10^{-4}	4 - 10

From: Chemical Treatment of Sewage and Industrial Wastes, National Lime Association.

Typical Applications of Chemical Coagulation

Suspended Solids Wastes: Coagulation is an ideal process for separation of suspended material from waste water. Since the suspended matter in domestic sewage normally amounts to 50 to 75 percent of the putrescible matter, many coagulation processes have been proposed for this waste. The principal assets of coagulation are ease of starting and stopping, ease of regulation of degree of treatment, and invulnerability to toxic materials. In addition, coagulation can remove certain materials, such as phosphates, which are passed by biological treatment processes. The principal limitations associated with chemical coagulation are relatively high cost of chemicals, the need for competent operation, and limited effectiveness for separation of soluble organic matter. The popularity of chemical coagulation as a process for treatment of domestic sewage has waned in favor of biological processes which are effective for treatment of both suspended and dissolved putrescible materials.

Chemical coagulation is particularly useful in situations where industrial wastes, toxic to bacteria, are present in sewage. In such cases, coagulation may serve as the entire treatment or as pretreatment for removal of toxic materials prior to biological treatment. The coagulants commonly used in the United States for domestic sewage are ferric chloride, ferric sulfate, chlorinated copperas and ferrous sulfate. Alum is a popular coagulant in Great Britain. The coagulants are used alone or in conjunction with lime or sulfuric acid. Adjustment of pH typically effects turbidity removal in the presence and absence of ferric coagulant.

The quantity of sludge produced from chemical coagulation is larger than from primary sedimentation because more solids are separated and the sludge may be low in solids content. Iron or iron-lime sludges are amendable to thickening to the point where dewatering by vacuum filtration is feasible. Alum sludges generally possess less favorable dewatering characteristics. Sludges from chemical coagulation of domestic sewage are suited to conventional anaerobic sludge digestion.

Colored Wastes: Waste waters from textile dyeing and finishing are ideal examples of wastes containing high concentrations of color. Chemical coagulation is the most widely used method of treating such wastes, and in certain situations it has effected up to 99 percent removal of color. Coagulants commonly used are ferrous and ferric sulfate, aluminum sulfate, lime, calcium chloride, and sulfuric acid. Of these, the combination of ferrous sulfate and lime has been in general most popular.

Oil Bearing Wastes: In the process of chemical coagulation of oil bearing waste water, the waste is dosed with approximately 400 mg/liter (400 p.p.m.) of ferric chloride, followed by sufficient hydrated lime slurry to produce a pH level of about 8.0. Either high calcium or dolomitic hydrated lime could be employed. The mixture is rapidly mixed for 2 minutes and flocculated at slow speed for 10 minutes. Following flocculation the mixture is allowed to stand quiescent for 2 hours to permit settling of floc. Settled sludge is transferred to the coagulant recovery tanks and the clarified water is discharged. Sufficient sulfuric acid is added to the sludge to dissolve the iron floc and to release adsorbed oil for skimming. The oil layer is skimmed from the surface and the dissolved iron salts are returned to the waste coagulation tank for reuse. Recovery of iron is about 90%. The oil content of the skimming vary from 50 to 90%.

Table 8. Treatment of Textile Dye Wastes by Chemical Coagulants

Waste	Coagulant Chemicals	Dosage ppm	pH Initial	pH Final	B.O.D. Initial	Color Initial	Removals % B.O.D.	Removals % Color
A	$FeSO_4$ Lime*	700 700	10.2	10.2	1028	40000+	41.5	91.0
A	Alum H_2SO_4	2510 780	10.2	6.0	1028	40000+	43.7	97.5
A	$CaCl_2$	2950	10.2	8.4	1028	40000+	42.5	85
B	$FeSO_4$	700	11.0	10.2	—	—	42.2	80
B	$FeSO_4$ Lime*	490 490	11.0	11.0	—	—	52.5	80
B	Alum H_2SO_4	2000 800	11.0	5.7	—	—	56.9	90
B.	$CaCl_2$	900	11.0	10.8	—	—	49.0	84

From: Chemical Treatment of Sewage and Industrial Wastes, National Lime Ass.

Waste A - Waste water from sulfur and indigo dye mill
Note: 14 days storage in lagoon effected no observable reduction in color
Waste B - Waste water from vat, sulfur, and indigo dyeing and finishing mill

* High calcium hydrate $Ca(OH)_2$.

\+ Representative value.

Theory of Chemical Precipitation

The addition of a reagent to react with and precipitate a pollutional constituent is one of the simplest of waste treatment processes in that the procedure consists of the adjustment of process conditions so that all but the desired or permissible residual of the constituent is precipitated from solution. When a simple precipitation is involved, the required process conditions can often be derived from solubility product calculations. The calculations become somewhat more involved if the precipitated compound be amphoteric (substances that may act as an acid or base), or if the composition of the waste be such that several compounds precipitate simultaneously.

Amphoteric precipitates such as hydroxides of chromium, aluminum, etc., exhibit minimum solubility at a distinct pH level and increase in solubility as the pH is shifted away (either above or below) the minimum point. The pH level of minimum solubility can be evaluated from solubility product and chemical equilibrium calculations.

When simultaneous precipitation of several compounds is involved, solubility product calculations can be applied to predict process conditions if the ratio of the concentrations of the precipitating substances be stable. However, the ratio of concentrations of components in waste water is variable in most cases, rendering process design on the basis of theoretical consideration applicable only to the assumed conditions. Similar limitations relative to

theoretical design may prevail when substances are present which form complexes (ions or compounds) with constitutents of the precipitate. Many metals are subject to complexification by ammonia, cyanide, polyphosphates, tartrate, oxalate and other substances. If the concentrations of complexing substances are known or assumed, allowance can be made in solubility product calculations, but the feasibility of theoretical analysis decreases with increased complexity of the waste.

Theory of Chemical Oxidation and Reduction

The generality that oxidation involves a loss of electrons and reduction involves a gain of electrons applies to most process reactions presented here. For simplicity, chemical oxidation may be compared to partial or complete combustion of susceptible waste constituents. The oxidation of cyanide in industrial waste with chlorine is a widely practiced process that is a classic example of both partial and complete chemical oxidation. For illustrative purposes, the reactions involved may be summarized as follows:

Series 1

$Cl_2 + 2NaOH$	=	$NaOCl + NaCl + H_2O$
$NaOCl + NaCN + H_2O$	=	$CNCl + 2NaOH$
$CNCl + 2NaOH$	=	$NaCNO + NaCl + H_2O$
$Cl_2 + NaCN + 2NaOH$	=	$NaCNO + 2NaCl + H_2O$

Series 2

$3Cl_2 + 6NaOH$	=	$3NaOCl + 3NaCl + 3H_2O$
$3NaOCl + 2NaCNO + H_2O$	=	$2NaHCO_3 + N_2 + 3NaCl$
$3Cl_2 + 2NaCNO + 6NaOH$	=	$2NaHCO_3 + N_2 + 6NaCl + 2H_2O$

The reaction indicated by the first set of equations represents the partial oxidation of cyanides to cyanates. The transformation of cyanides to cyanates is accompanied by a significant reduction in volatility and roughly a thousand fold reduction in toxicity. Effluents containing cyanates may occasionally be acceptable for discharge to city sewerage systems or to biological oxidation processes. It is important that recognition be given to the indicated formation of toxic and volatile cyanogen chloride as an intermediate reaction product. An accumulation of cyanogen chloride is an undesired possibility inasmuch as the reaction between hypochlorite and cyanide to form cyanogen chloride is practically instantaneous, whereas, essentially complete hydrolysis of cyanogen chloride takes from a few minutes to several hours or longer, depending upon process conditions. The presence of excess alkalinity both accelerates hydrolysis and decreases the volatility of cyanogen chloride, therefore, the level of pH for the reaction is generally maintained from 10.0 to 11.5. The formation of chloramine has been reported as a by-product to partial oxidation of cyanide by chlorination.

The reaction presented by the second set of equations represents the complete oxidation of cyanate, the final step in the conversion of cyanide to carbon dioxide and nitrogen. The reaction is accompanied by the simultaneous destruction of chloramine and ammonia to nitrogen and water. Since hypochlorous acid oxidizes cyanate ion more rapidly than hypochlorite ion, the pH level is generally controlled within a range of 7.0 to 9.5 if rapid reaction (30 minutes or less) be sought. Lower pH levels are avoided to prevent formation and emission of explosive and noxious nitrogen trichloride. The theoretical chemical requirements on a weight basis for oxidation of cyanide to carbon dioxide and nitrogen as illustrated in the first and second set of equations are 6.73 parts chlorine per part cyanide, and 1.13 parts caustic soda per part chlorine. In practice, complete oxidation normally requires a minimum dosage of at least 7.4 parts chlorine per part cyanide, and an overdose of 50 percent is not usual. Most of the chlorine required in an overdose is consumed through reaction with reducing agents other than cyanide. The reactions for oxidation of cyanide to cyanate and cyanate to carbon dioxide

and nitrogen are exothermic. In addition to gaseous chlorine, sodium and calcium hypochlorites have been commonly employed as oxidants for cyanides. Likewise the alkali employed for control of pH level may be high calcium lime or sodium carbonate in lieu of sodium hydroxide.

The principal application of chemical reduction in waste treatment is for the transformation of hexavalent chromium to trivalent chromium. The reduction renders the chromic ion amenable to separation from solution in conjunction with other metallic salts by alkaline precipitation. Gaseous sulfur dioxide is a widely used reducing agent for the process. The reactions involved may be illustrated as follows:

Series 3

$$3SO_2 + 3H_2O = 3H_2SO_3$$

$$3H_2SO_3 + 2H_2CrO_4 = Cr_2(SO_4)_3 + 5H_2O$$

$$Cr_2(SO_4)_3 \quad 3Ca(OH)_2 = 2Cr(OH)_3\downarrow + 3CaSO_4$$

$$3SO_2 + 2H_2CrO_4 + 3Ca(OH)_2 = 2Cr(OH)_3\downarrow + 3CaSO_4 + 2H_2O$$

The kinetics of the reduction of chromium by sulfurous acid are favored by low pH. A pH level of 2 to 3 is common for situations requiring quantitative reduction. At pH levels above 5, the reaction rate is extremely sluggish. Oxidants such as dissolved oxygen and ferric iron interfere with the process by consuming the reducing agent. Other reducing agents commonly employed for reduction of hexavalent chromium are ferrous sulfate, sodium bisulfite, and sodium metabisulfite. The reaction kinetics for sulfites are theoretically similar to those presented for sulfur dioxide. Reduction of chromium by ferrous sulfate is also most effective at pH levels of less than 3.0.

Precipitation of chromic ion as a hydrous hydroxide may be effected by neutralization of the solution to a pH level near 8.5. The precipitate is amphoteric, therefore, it is important that the level of pH be carefully controlled if low residuals of effluent chromium are to be realized. Lime or sodium hydroxide are generally employed to effect neutralization.

Metal Finishing Waste: The cyanide waste from metal finishing operations is treated by the alkaline chlorination process for oxidation of cyanides to carbon dioxide and nitrogen. The treatment process is illustrated by the first and second set of equations above. The treatment units consist of an equalization tank of 4-hours detention and three reaction tanks connected in series, each having a theoretical detention time of about 100 minutes. Each reaction tank is instrumented with electronic recorder-controllers to automatically maintain desired conditions in respect to pH level and oxidation reduction potential (ORP). The chromate waste from metal finishing operations is treated by reduction with sulfur dioxide, as illustrated in the equation Series 3. The treatment units consist of an equalization tank of 2-hours detention and two reaction tanks connected in series, each having a theoretical detention time of 45 minutes. The reaction tanks are instrumented with electronic recorder-controllers to automatically control process conditions in respect to pH level and the oxidation reduction potential (ORP).

Slaughterhouse Waste: Liquid waste from small slaughterhouses has been successfully treated by chemical oxidation with chlorine. The partial oxidation effects precipitation of fresh animal protein, rendering it separable by chemical coagulation. Prior hydrolysis of proteins by in-plant cooking impairs process efficiency.

Phenolic Waste: Chemical oxidation is effective for removal of phenolic constituents from wastes and from water supplies. Chlorine, chlorine dioxide, ozone, and potassium permanganate have been employed as oxidants, with chlorine having the widest application.

Theory of Chemical Neutralization

An adjustment of pH toward neutrality entails the reaction of compounds bearing hydrogen and hydroxyl ions to form water and salts as illustrated by the following equations.

$$H_2SO_4 + 2NaOH = Na_2SO_4 + 2H_2O \quad (1)$$

$$H_2SO_4 + Ca(OH)_2 = CaSO_4 + 2H_2O \quad (2)$$

$$2H_2SO_4 + Ca(OH)_2 \cdot MgO = CaSO_4 + MgSO_4 + 3H_2O \quad (3)$$

The salt product formed by reaction of an acid with an alkali may be highly soluble as in the case of sodium and magnesium sulfate (equations 1 and 3) or slightly soluble as in the case of calcium sulfate (equations 2 and 3). If the solubility product of a salt be exceeded during neutralization, some precipitation may be expected. The formation of precipitate is generally considered undesirable, but in certain instances the discharge of effluents high in dissolved salt content may also be detrimental to receiving waters.

The reaction products of neutralization of acids, such as hydrochloric, nitric or acetic, are highly soluble for all commercial alkalies. The neutralization of sulfuric and phosphoric acids with sodium alkalies give soluble reaction products, whereas calcium-base alkalies (e.g., limes, limestones) yield some products of low solubility. In the absence of precipitation of impurities, the quantity of sludge produced usually can be estimated from calculation of the quantity of product formed less its prevailing solubility. The solubility is estimated from a solubility product calculation.

In the case of sulfuric acid neutralization, the calcium sulfate reaction product may form a supersaturated solution in situations where the solubility is exceeded. Normally the supersaturation will gradually dissipate through deposition of gypsum (after-precipitation) possibly over a period of several days. The precipitate may take the form of loose crystals or a consolidated scale deposit on conduit or vessel surfaces.

Impurities, such as metal ions, that precipitate upon neutralization, are widely associated with acid wastes. The presence of such impurities usually commits the waste treatment operation to separation, handling and disposal of sludge irrespective of the alkaline agent employed. Impurities frequently decrease reaction rates between acid solutions and alkaline agents.

Table 9. Cost Comparison of Commercial Alkaline (Neutralizing) Agents, 1964 Prices.

Agent	Chemical Formula	Price $/ton	Basicity Factor	Cost ($/ton of basicity)	Relative Cost
Sodium Hydroxide[a]	NaOH	104.00	0.687	151.38	8.50
Sodium Carbonate[b]	Na_2CO_3	37.00	0.507	72.98	4.10
High Calcium Hydrate	$Ca(OH)_2$	17.25	0.710	24.30	1.37
Dolomitic Hydrate	$Ca(OH)_2 \cdot MgO$	17.25	0.912	18.91	1.06
High Calcium Quicklime	CaO	16.75	0.941	17.80	1.00
High Calcium Limestone[c]	$CaCO_3$	10.50	0.489	21.47	1.21
Dolomitic Limestone[c]	$CaCO_3 \cdot MgCO_3$	10.50	0.564	18.62	1.05
Dolomitic Quicklime	$CaO \cdot MgO$	16.75	1.110	15.09	0.85

From: Chemical Treatment of Sewage and Industrial Wastes, National Lime Association.

[a] Solid, 76 percent Na_2O.
[b] Powder, 58 percent Na_2O.
[c] Pulverized - basicity somewhat dependent upon application.

Several procedures, in addition to excess dosage, may be employed to improve the performance of alkaline agents of marginal reactivity. For low volumes of concentrated acid, it may be feasible to heat the solution to accelerate the reaction rate. For carbonate alkalies, aeration can be employed to release carbon dioxide to effect an increase in the driving force of the reaction. For solutions containing iron, aeration can be employed to lower pH through conversion of ferrous ion to ferric ion thereby facilitating the neutralization reaction. The effects of these procedures for neutralization of pickle liquor with various alkali agents are illustrated in Table 10.

Table 10. Reactivity of Alkaline Agents with Pickle Liquor Containing 60 Grams of Iron and 200 Grams of Sulfate per Liter

In each case, a 5 percent excess of alkaline agent, in terms of basicity, is added. Decreased reactivity is indicated by results showing grams per liter of unprecipitated iron remaining after a 6-hour reaction period, except where iron is absent in a shorter time.

	Conditions of Reaction			
Agent	Room Temp. and No Aeration	60° C. and No Aeration	Room Temp. with Aeration	60° C. with Aeration
NaOH	——[b]	——[b]	——[b]	——[b]
Na_2CO_3	0 in 0.75 hr.	0 in 0.75 hr.	0 in 0.75 hr.	0 in 0.5 hr.
CaO	0 in 0.25 hr.	0 in 0.25 hr.	0 in 5 min.	0 in 5 min.
CaO · MgO	1.88 hr.	3.14 hr.	1.04 hr.	0.30 hr.
$Ca(OH)_2$	0 in 0.5 hr.	0 in 0.5 hr.	0 in 0.5 hr.	0 in 0.5 hr.
$Ca(OH)_2$ · MgO	1.23 hr.	1.53 hr.	0.55 hr.	0 in 3.5 hr.
Acetylene Sludge[a]	1.66 hr.	1.04 hr.	0 in 3.5 hr.	0 in 3.5 hr.
$CaCO_3$[c]	20.40 hr.	18.80 hr.	2.95 hr.	0.03 hr.

[a] $Ca(OH)_2$ waste product.
[b] Reaction practically instantaneous.
[c] Pulverized limestone.

From: Chemical Treatment of Sewage and Industrial Wastes, National Lime Association.

Scale Formation and Control: Scale formation on equipment and in effluent pipes is a problem commonly associated with neutralization of waste solutions containing sulfuric acid with calcium-base alkalies. The principal cause of severe scale formation is the tendency of calcium sulfate to form supersaturated solutions that deposit gypsum on standing until equilibrium solubility is attained. The rate of approach to equilibrium solubility is sluggish even in the presence of previously precipitated material. The primary factors affecting scale formation are (a) temperature, (b) acid composition, (c) acid concentration, (d) alkali agent and (e) degree of neutralization or effluent pH.

It is apparent that the maximum attainable supersaturation is increased as the temperature is lowered. The effects of acid composition, acid concentration and alkali agent on supersaturation must be considered simultaneously. The combination of acid concentration and acid composition fix the quantity of sulfate available for formation of calcium sulfate upon neutralization. The calcium content of the alkali agent dose represents the calcium available for formation of calcium sulfate upon neutralization. If the solubility product of gypsum be not exceeded during neutralization, calcium sulfate will not precipitate during or following the neutralization reaction. However, if the solubility product of gypsum be exceeded but the solubility product of hemihydrate be not exceeded, a supersaturated solution may be expected to form which will deposit an after-precipitate of gypsum until it is at equilibrium with the gypsum solubility product. If the solubility products of both gypsum and hemihydrate be exceeded, calcium sulfate will be precipitated during neutralization; and the extent of supersaturation in the neutralized mixture will depend upon the quantity of calcium sulfate precipitated, the temperature, and the time of mixing. Available evidence suggests that if the calcium sulfate formed as the reaction product amounts to 2 to 3 times the solubility of calcium sulfate hemihydrate at the prevailing temperature, the resulting supersaturation in the neutralized mixture will be absent or slight. With pure sulfuric acid solutions exceeding 1.6 percent

concentration and at room temperature, post-neutralization deposition of calcium sulfate is absent or slight following neutralization with high calcium lime. For dolomitic lime neutralization to acidic or neutral pH ranges, the corresponding value of concentration at which sludge formation controls supersaturation is about 2.5 percent sulfuric acid.

Overneutralization to pH 9 to 11 normally increases the magnitude and improves the stability of supersaturated calcium sulfate solutions. In addition, the tendency for post-neutralization deposition to take the form of a strongly adhering hard scale is increased dramatically. The nature of the deposit formed also differs, depending upon the source and type of lime, some limes being more prone to scale formation than others. Neutralization to pH levels less than 5.0 infrequently causes problems due to scale formation inasmuch as post-neutralization deposition normally forms as a granular sludge. At pH levels between 5.0 and 9.0, deposits formed may be granular sludge or scale depending upon the lime and waste characteristics. As a rule, deposition from dolomitic lime neutralization tends to form a granular sludge unless gross overneutralization above pH 9.0 be practiced. Overneutralization with dolomitic lime yields scale tendencies similar to overneutralization with high calcium lime.

The problem of extensive calcium sulfate scale formation is confined to situations where sufficient calcium sulfate is formed to exceed the solubility product of gypsum, but where insufficient calcium sulfate is formed to grossly exceed the solubility product of calcium sulfate hemihydrate. When sufficient calcium sulfate precipitation occurs, it acts as seed nuclei for induced desupersaturation of the solution. Control of supersaturation can also be effected by neutralization in the presence of previously precipitated calcium sulfate where neutralization in the presence of 50 to 60 grams per liter of previously precipitated calcium sulfate sludge effectively controlled the level of supersaturation and resultant after-precipitation. The process is similar to that proposed for concentration of sludge; therefore, sludge concentration benefits are realized simultaneously. It has also been demonstrated that stabilization of the neutralized mixture in respect to calcium sulfate concentration is effected by addition of gypsum sludge after neutralization or by passing the neutralized mixture through a bed of rock gypsum granules. The application of solids contact-type units is recommended for neutralization of dilute waste sulfuric acid solutions to minimize the volume of sludge to be handled and the tendency for scale formation. The effectiveness of the process to stabilize calcium sulfate concentration following lime neutralization of complex industrial wastes has been confirmed.

Control of scale formation can also be realized through application of sodium alkalies so as to avoid formation of calcium sulfate on neutralization, or by dilution before or after neutralization to reduce the concentrations of dissolved calcium and sulfate ions to such an extent that the solubility product of gypsum be not exceeded. It is desirable that overneutralization of waste acid be avoided with lime neutralization processes because carbonation of solutions containing free calcium hydroxide may result in precipitation of calcium carbonate which can serve as a cementing agent for formation of scale.

Instrumentation Control of Neutralization Processes: Continuous flow neutralization processes were among the first industrial waste treatment operations to be automated through instrumentation. The heart of the instrumentation is one or more pH recorder-controllers employing glass-calomel electrode systems. In some designs, particularly batch operation, the controllers regulate the feed of neutralizing agent in response to signals transmitted from pH electrodes immersed in the reaction tank. Regulation of feed is accomplished by electrically or pneumatically-operated valves controlled by transmitters, which in turn are governed by the pH controllers. Pneumatic operation has been the more popular. Other designs have provided for automatic regulation of waste feed into the reaction tank as well as for feed of neutralizing agent. Designs have also incorporated regulation of feed of neutralizing agent in response jointly to incoming flow and level of pH in the reaction tank. Many workable schemes are possible. The use of multiple reaction tanks in series and of two stage addition of neutralizing agent have been advantageous for non-instantaneous reactions. Such an arrangement offers improved efficiency through reduction of short circuiting of inflow but may entail added capital outlay for equipment.

Pickle Liquor Neutralization: Steel companies use sulfuric acid in pickling operations which yield spent pickle liquor containing ferrous sulfate and sulfuric acid amounting to about 70

grams of iron and 170 grams of sulfate per liter. Neutralization of the waste has been applied successfully to both small and large scale operations. For small scale operations of less than 5,000 gallons per day, batch neutralization with lime is a simple process.

The steps in the operation of the process are as follows:

1. Determination of the volume of acidity of the stored acid solution so as to enable calculation of the required dosage of lime.

2. Add water to the reaction tank so as to suspend the lime in a 20 percent slurry as CaO or CaO·MgO. The water should be hot if quicklime is to be employed.

3. Start the slurry pump connected for recirculation and add the correct number of bags of lime to provide the determined dosage.

4. Open the eductor in the pump discharge to draw from the acid storage tank.

5. When neutralization is completed, pump the neutralized mixture to disposal (e.g., lagoon, municipal sewer, etc.).

Where space is limited and acid waste is concentrated, the following features can be incorporated in the process: (a) minimization of the volume of neutralized mixture by use of concentrated lime slurry, (b) operation of the process to produce a neutralized mixture with good filtration properties and (c) vacuum filtration of the neutralized mixture for separation of liquid from solids. The batch-type process operates on a scale of about 600 gallons of pickle liquor per batch. The volume increase due to addition of neutralizing agent is minimized by use of lime slurry containing from 2.5 to 3.0 pounds of quicklime per gallon of slaking medium. The slaking medium is composed of a mixture of from 50 to 75 percent by volume of neutralized filter effluent, the remainder being water. The use of filter effluent for lime slaking retards the reaction rate, but it improves the filtration properties of the neutralized mixture. Slaking of lime in the reaction vessel prior to acid addition is recommended to conserve the heat generated upon hydration.

Controlled Oxidation Methods of Neutralization: A unique neutralization process for pickle liquor has been developed on a laboratory scale by Hoak and Sindlinger.* The process employs high temperature, controlled oxidation of iron, and novel neutralization procedures to obtain remarkably concentrated sludges with outstanding filtration characteristics. The process appears to be amenable to either batch or continuous operation.

For batch operation, a slight excess (e.g., 0-5%) of alkaline agent is added to a volume of previously neutralized slurry in a reaction tank. The agitation tank is equipped for mechanical agitation and aeration. With the agitator on, pickle liquor is fed at a continuous rate into the tank, and aeration is regulated to effect oxidation of sufficient ferrous ion to ferric ion so as to produce a ferric to ferrous ratio of from 2 to 5. The temperature is maintained above 75°C. throughout the process to induce formation of dense ferroso-ferric oxide precipitate. Among the suitable alkaline agents are high calcium lime, dolomitic lime, magnesia, or sodium hydroxide.

A controlled oxidation-conductance method of continuous neutralization of waste pickle liquor was developed by the A.O. Smith Corporation of Milwaukee, Wisconsin. The process consists of mixing waste acid with acetylene sludge, $Ca(OH)_2$, at a point immediately below the mixing impeller of an upflow reaction tank. A small amount of compressed air is also added just below the impeller. The reaction effected consists of neutralization of acidity and partial oxidation of ferrous iron to ferric iron. The degree of neutralization is maintained between pH 7 and 8 by a conductivity cell-controller which regulates the addition of acid to the reaction tank. The neutralized mixture overflows to a rotary disc vacuum filter for separation of suspended

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* Ind. Eng. Chem., 41, 1, 65-70, 1949.

solids. The filter cake is trucked to disposal as secondary fill, and the filtrate is used to slurry the acetylene sludge or is discharged to sewers.

Limestone Neutralization: Neutralization of waste acid with limestone almost invariably appears attractive from the cost standpoint; however, past experience with the process has recorded a considerable incidence of failures. Consequently, the process has a reputation of limited reliability. Probably the principal reason for failure of the process is insufficient process development to establish that the process is really applicable for the specific waste to be neutralized. It is also likely that some failures are due to unanticipated in-plant process changes which result in the discharge of fouling agents. The discharge of troublesome concentrations of substances such as oils, greases, sulfate, phosphates, fluorides, etc., may foul the active surfaces of a limestone bed and thereby disrupt the process. To overcome these problems, the General Electric Company's Silicone Products plant at Waterford, N.Y., improved its neutralization process by a revision incorporating: (a) more equalization of flow prior to neutralization, (b) increased fouling protection by sedimentation for all flows containing silicone gel, (c) increased flow rates in the limestone bed to provide 20 to 30 gpm per sq. ft., (d) improved influent distribution to the limestone bed through installation of a perforated pipe feed system, and (e) a pH recorder to monitor the effluent pH. The revision improved particle suspension (limestone granules 0.25 in. or smaller), minimized channeling and made the bed completely self cleaning. For future plants, deeper limestone beds (some designers suggest 5 - 8 ft. of expanded bed) and carefully engineered equalization are recommended.

The neutralizing unit appears capable of operation at flow rates as high as 13.6 gpm per sq. ft. of 1.0 percent HCl. The pH of the effluent from less concentrated acid solutions normally ranges from 4 to 6. Labor requirements average 2 to 3 man hours per day, seven days a week.

Lime Neutralization of Dilute Acid: Neutralization with high calcium or dolomitic lime is the most popular method of treatment of dilute acid wastes. The process offers flexibility, reliability and economy, and can adequately neutralize the combined plant waste from a rayon plant consisting of a complex mixture of substances including sulfuric acid, sulfides, polysulfides, zinc sulfate, treated domestic sewage, sodium hydroxide, and various organic compounds. The acidity of the waste is generally less than 3000 mg/l as sulfuric acid.

Scale formation has occurred when the acid concentration exceeded about 1500 mg/l in the waste solution. The scale forms on treatment chambers, flumes and pipes. The remedy for the problem is the temporary substitution of dolomitic for high calcium lime, which does not cause scale formation at the prevailing levels of sulfate concentration. Dissolution of existing scale deposits has been observed with dolomitic lime neutralization of acid solutions containing less than 3000 mg/l of acidity as sulfuric acid.

Waste waters containing chromium or ferrous iron are collected separately from other wastes and subjected to a chromate reduction process prior to joining the main waste stream going to neutralization. Instrumentation for the reduction process consists of oxidation-reduction potential and pH control systems. The ORP system controls the addition of ferrous sulfate solution on the basis of the oxidation-reduction potential as determined by platinum and reference electrodes.

Filtering Devices.

Whereas water depends on the mechanical straining ability of the filtration process for adequate function, sewage depends on the biological decomposition ability of the microscopic life in the filter beds for adequate function. There are, however, sewage filtering devices of various types, such as magnetite filter and coarse sand filters, which depend on the mechanical straining ability for its function, but these are few as compared with biological filters. Biological filters depend on the nitrifying bacteria that live in the filter bed for the decomposition of the organic matter in the sewage, as is indicated by the reduction of the content of organic nitrogen and free ammonia, and the consumption of oxygen in the influent, and the increase of nitrites, nitrates, and dissolved oxygen in the effluent. The smaller the particles of filtering material that make up the filter bed the greater is the surface area on which the microscopic organisms can exist. But the difficulties that may arise from filter clogging and inhibition of aeration limit the smallness of size of the filtering material.

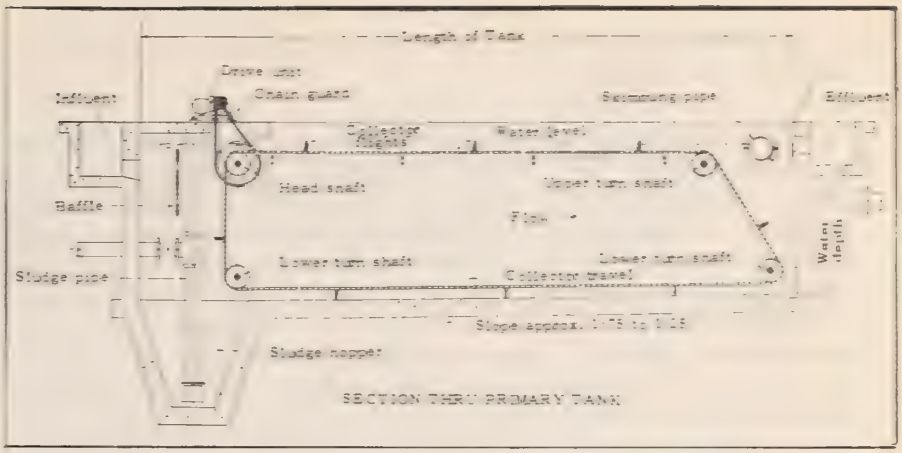


Fig. 4 Rectangular Sedimentation Tank with Sludge Collector and Hopper

Trickling Filters - These devices are a development from contact beds which have almost gone out of use, and which are usually watertight tanks filled with coarse material which are alternately filled, allowed to stand and emptied, and then allowed to stand empty while the solids which settled on the contact material become oxidized. Sometimes tanks with open brick walls are used to boost aeration. Attempts to increase the volume of sewage treated in a unit of time, by distributing the sewage over the surface of the bed and allowing it to trickle through, led to the development of the trickling filter.

Trickling filter beds are made up usually of crushed stone, limestone, or gravel, 1 to 3 inches in diameter, although coke, slag, anthracite, laths, ceramic material, brushwood, etc. are used. Shallow filters vary from 3 to 5 feet in depth, while deep filters vary from 6 to 12 feet, but commonly 6 to 7 feet. The shallow filters are most commonly used in series or parallel when high rate filtration is practiced with recirculation of the effluent. When settled sewage is sprinkled over the bed, it soon becomes covered with an active film of microorganic material which oxidizes the organic sewage matter by aerobic action. Better nitrification is obtained with deep beds. Sedimentation of the effluent is usually necessary to remove the settleable solids. The filters are drained by an underground system of half-round, vitrified tile pipes which are perforated, or open jointed; or by means of grooves or channels. Ventilation is aided by proper underdrainage. Sewage may be distributed over the surface of a trickling filter bed by:

1) Fixed spray nozzles - used for large beds of rectangular or other shape. (Fig. 10)
2) Revolving distributor arms - used for circular beds not more than 150 - 200 feet in diameter. (Fig. 9)
3) Motorized disc distributors for filters up to 35 feet in diameter which throw out the sewage horizontally from the center of the tank. (Fig. 11)
4) Travelling distributors - moved back and forth over rectangular beds.

The loss of head in a rotating distributor is much less than needed for spray nozzles - about 18" as compared to 8 - 10 feet. This is an important factor in the choice of the system to be used.

To abate fly nuisances the beds are periodically flooded to flush out the larvae.

The standard trickling filter is dosed intermittently and may be called a "high momentary rate" filter. Recently a continuous flow trickling filter has come into use which is called "high capacity" filter. The distinguishing features of the latter are the continuous dosing of the filter bed and the recirculation of effluent. Although the momentary rate of dosage be low, 4 to 10 times and even more sewage can be applied per unit of area than by the intermittent method. The recirculation technique is used to maintain an even flow on the filter during varying inflow of sewage at the plant. This prevents the beds from drying out, and maintains a maximum population of microorganic life in the bed. The flora and fauna are of the same types as in the standard trickling filters, and like the latter, are also of shallow and deep types. The advantages of the high capacity trickling filter are:

1) Lower initial cost - they are smaller and use less broken stone.

2) Flies, freezing, odors, and ponding of surfaces are practically eliminated.

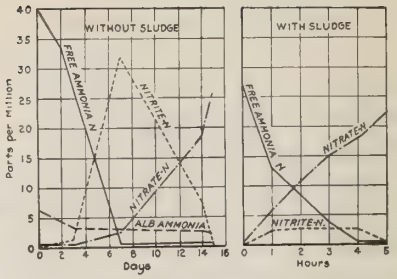
3) Handles greater organic load.

4) Gives better effluent.

5) Continued operation cost is about the same as standard type.

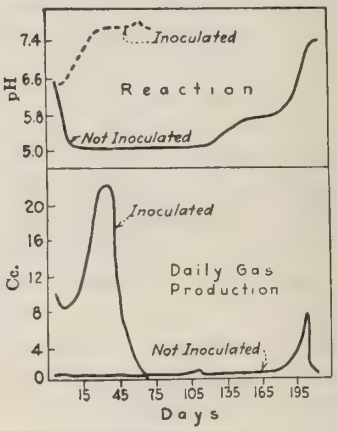
6) Treatment process is not materially affected by fluctuations in strength of raw sewage or by industrial waste discharges that are not in excess.

Some of these high capacity filters are patented; the difference is mainly in the recirculation of the filtered sewage and the mode of distribution. The following systems are used:



From: Sewerage & Sewage Disposal, Metcalf & Eddy

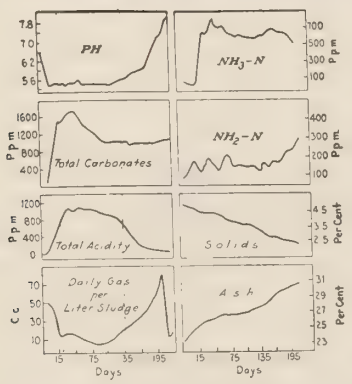
Fig. 5 Effect of Sludge Return on Aerated Sewage



From: Sewerage & Sewage Disposal, Metcalf & Eddy

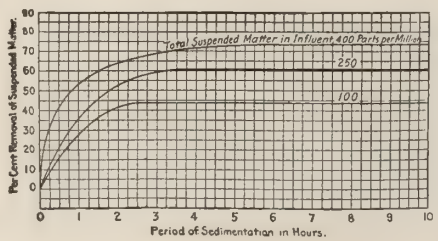
Fig. 6. Effect of Seeding upon the Rate of Digestion of Sludge

Biofilters, patented by the Dorr Co. and produced by that company and the Link Belt Co. In these filters the filter discharge is returned, all or in part, from the secondary clarifier to the raw sewage pump pit, resulting in a reduction of the initial B. O. D.



From: Sewerage & Sewage Disposal, Metcalf & Eddy

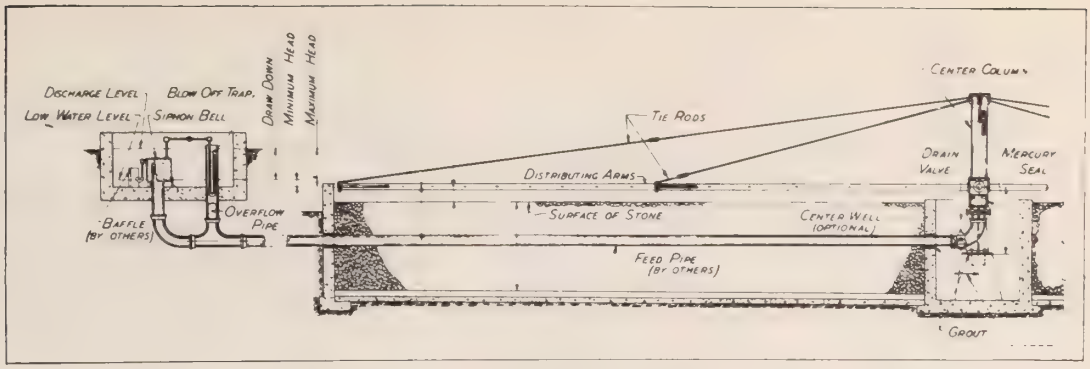
Fig. 7. Characteristics of Digesting Sewage Sludge. NH_2-N represents amino nitrogen. Dotted lines approximately indicate the 3 phases of digestion.


Total Suspended Matter in Influent 400 Parts per Million
250
100
Per Cent Removal of Suspended Matter
Period of Sedimentation in Hours.

From: Sewerage & Sewage Disposal, Metcalf & Eddy

Fig. 8. Sedimentation of Sewage

This graph shows clearly that the retention period for average strength sewage (300 p. p. m.) should not extend beyond a maximum of 3 hours.



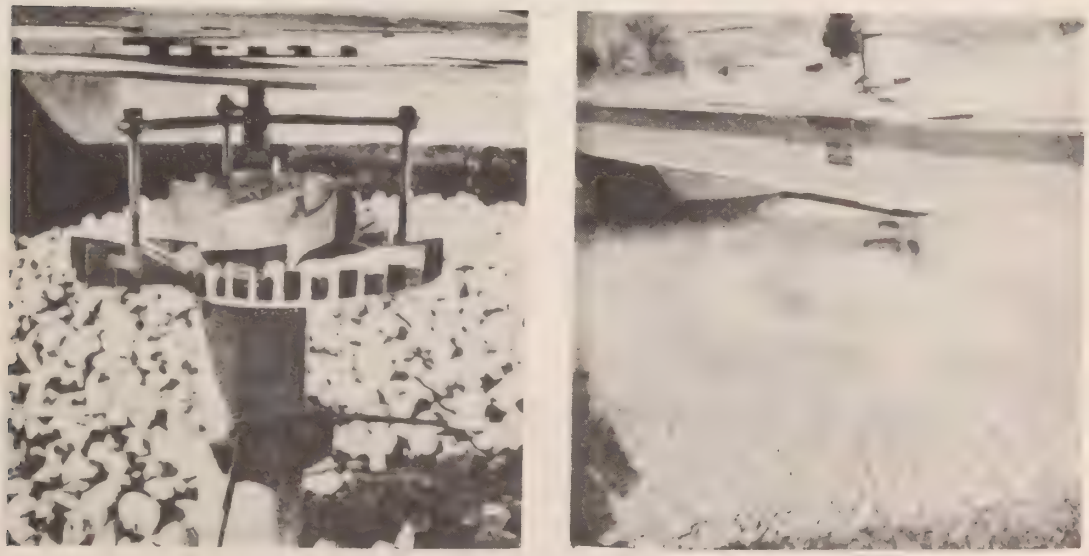
Section through low rate filter showing siphon, feed pipe and distributor.

From Public Water Magazine

Fig. 9. Trickling Filter with Rotating Arms

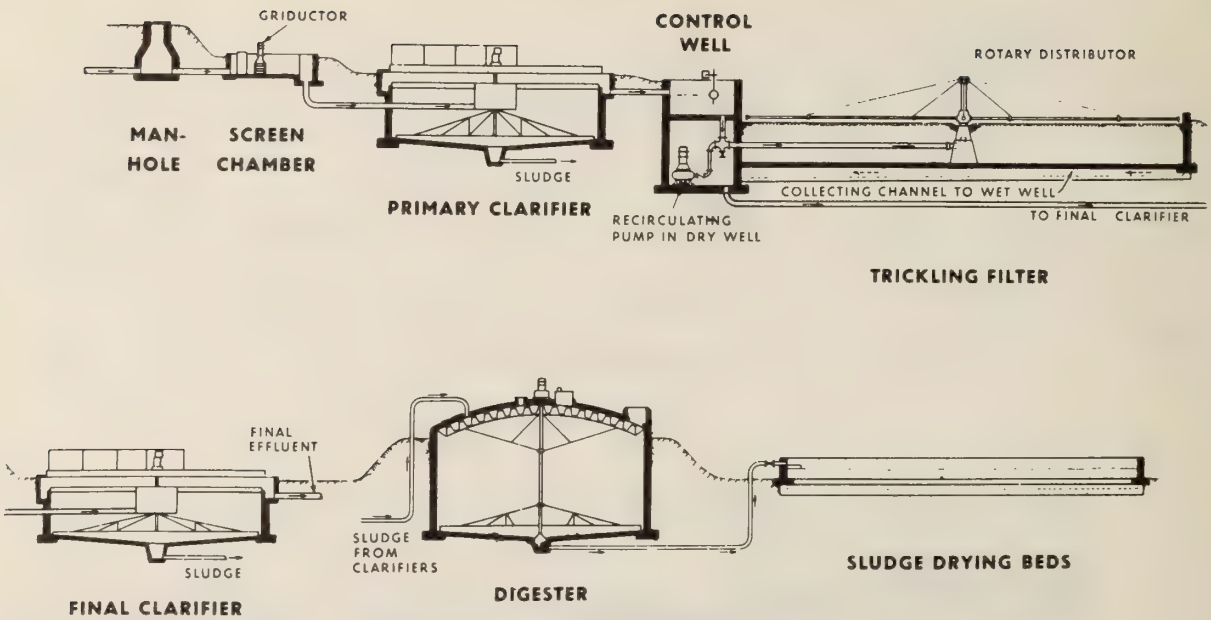
From Pacific Flush Tank Co. Catalog

Fig. 10. Trickling Filter with Spray Nozzles



From Public Water Magazine

Fig. 11. Motorized disk Distributors for High Rate Filters



From: International Filter Co.

Fig. 12. Sectional View of a Typical Sewage Plant

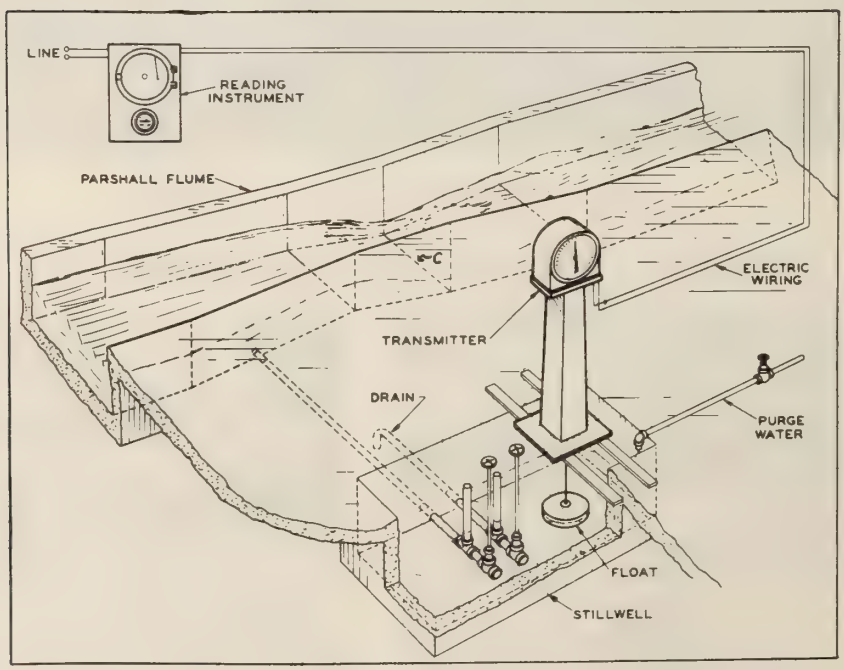


Fig. 13. Diagrammatic Sketch of Parshall Flume

Automatic Sewage Flow Recording Installation.

The height of the water above the crest C as measured in the stilling well by means of the float is in direct relation to the flow of water which can be graphically recorded.

Aerofilters are made by the Yeomans Bros. and the Lakeside Engineering Corp. This system is not based on large percentages of recirculation but on improved distribution of the sewage over the filter area. For this purpose multiple arm and also revolving disc distributors are used which produce a more equal dosage per square foot of filter surface. The actual rate of sewage application is thereby smaller and the filter as a whole can treat a much larger volume of sewage per acre. Disc distributors are used for flows below 375 g. p. m.

Accelofilters are the product of the International Filter Co. (Infilco) Fig. 12, and are based on the direct recirculation of unsettled effluent of a biological filter to the inlet of the filter distributor for the purpose of producing intensified biological oxidation by means of the active aerobic organisms in the effluent.

Recirculation rates for high capacity filters vary with the raw sewage B. O. D. from 0.75 for a B. O. D. of 150 p. p. m. to 4.5 for a B. O. D. of 750-900 p. p. m. Those for the clarifiers through which the recirculated sewage flows are obtained by adding 1. Such filters are designed for average 24 hour dosage rates varying from 10 to 30 million gallons per acre per day including recirculation.

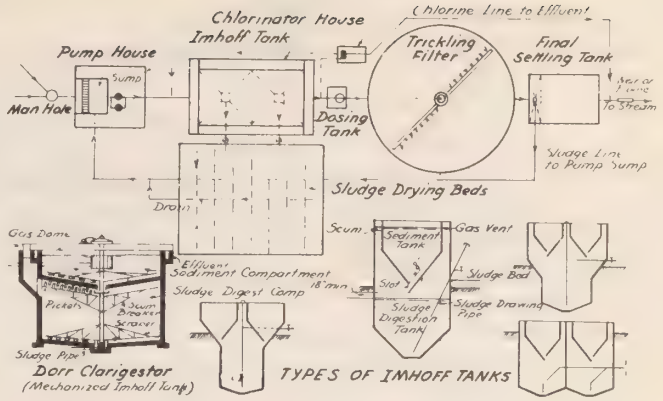


Fig. 14. Imhoff Tank - Trickling Filter Plant

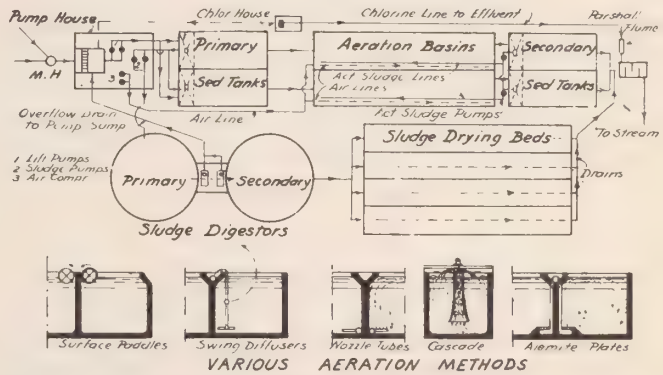


Fig. 15. Lay-out of Activated Sludge Sewage Plant

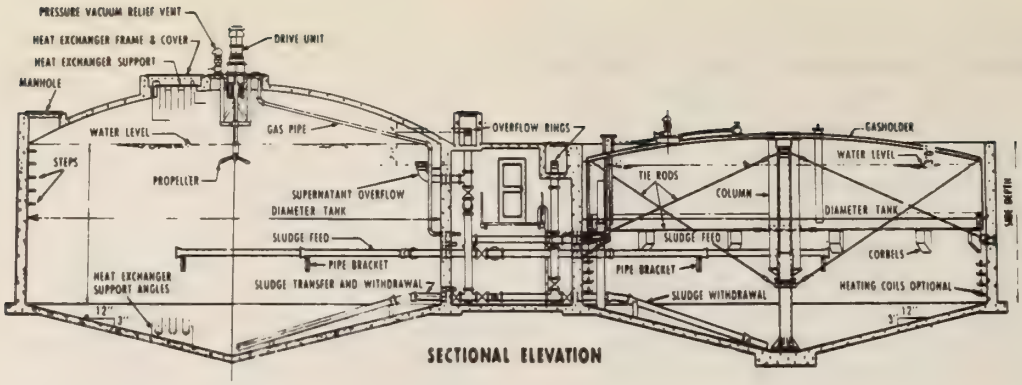
The design of the high capacity type tank resembles the standard trickling filter except the adequacy of ventilation must be taken into consideration and greater capacity in the underdrainage system must be provided.

The loadings for standard and high capacity filters are expressed in the following terms:

	Standard Filters	High Rate Filters
Million gallons per acre per day	2-4	15-30
Million gallons per day per acre-foot (of filtering material)	0.3-0.6	2.5-4.0
B. O. D. in pounds per acre-foot per day	200-400	1800-3000
B. O. D. in pounds per cubic yard (of filtering material)	0.1-0.2	1.2-3.4

The effluent from most primary treatment processes usually prove satisfactory influent for a trickling filter, except effluent from a septic tank which may be too stale and detrimental to the biological action in a filter.

High capacity filters may operate alone, in two stages, or even three stages, with or without intermediate sedimentation between stages. Multiple stages are used on strong sewages, sewages receiving wastes from canning plants, or when high quality of effluent is desired.



Primary Tank with Fixed Cover

Secondary Tank with Heating Coils and Floating Roof

Fig. 16 Sludge Digestion Tanks

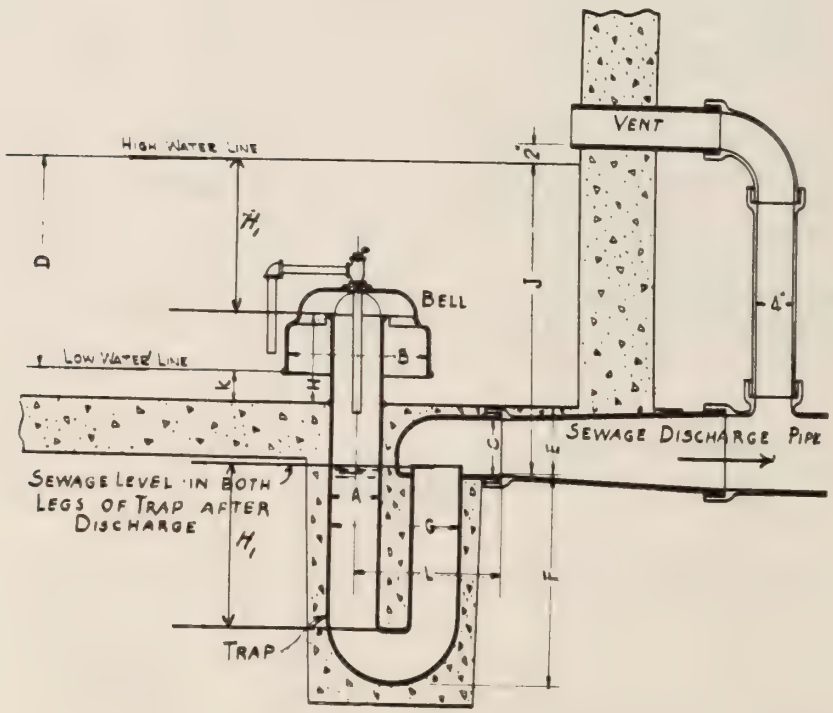


Fig. 17

Diagrammatic Illustration of Siphon For intermittent Sewage Dosage

The sewage in the tank and trap is shown at the position of start of siphon action. Air will be expelled from the trap and the sewage will rush out until the air entering under the rim of the bell breaks the siphon action. The tank will then fill up again.

The efficiency of the standard filter, including primary and final settling varies from 70 to 90% B. O. D. reduction; 80 to 90% suspended solids removal; 90 to 95% bacterial removal.

The efficiency of the high capacity filter, two-stage treatment, and a recirculation ratio of 1. 0 in each stage should show a 95% B. O. D. reduction.

Activated Sludge Process (Fig. 15)

The activated sludge process, like other biological processes fundamental in water and excreta control, depends to a large extent on the nitrogen and other cycles. Activated sludge is similar in character, composition, and action to the biological film in a trickling filter. When sewage is mixed with a sufficient amount of biologically active sludge, the finely divided suspended and dissolved solids are transferred to the surface of the sludge floc, which, when supplied with oxygen, oxidizes the organic material of the sewage (Fig. 5). The floc settles and leaves a clear, colorless, odorless, relatively stable liquor high in dissolved oxygen and low in B. O. D. Part of the settled floc, drained from the final settling tank by gravity or pumping, is returned in an amount of 15% to 25% of the average sewage flow to the influent of the aeration tank to form the mixed liquor. This return of sludge is the essence of the activated sludge process. The concentration of suspended solids in the mixed liquor mechanical-agitation aeration tanks usually varies from 800 to 1200 p. p. m. and where air-diffusion (by air compressors) aeration is used, from 1500 to 2500 p. p. m. Mechanical agitation supplies oxygen by continually mixing the dissolved oxygen on the surface into the sludge. Air-diffusion supplies oxygen to the mixed liquor in the aeration tank by the solution of the oxygen from the air bubbles of air forced through the liquor. In order to maintain at least 1 p. p. m. of dissolved oxygen in the effluent from the aeration tank, it is necessary to apply from 0. 2 to 1. 5 cubic feet of free air per gallon of treated sewage, depending on the character of the sewage.

The design of activated sludge plants provide:

1) A system of aeration tanks for bringing the settled sewage into contact with activated sludge for a sufficient length of time (3 to 18 hours, but averaging 6 to 8 hours).

2) Methods of keeping the sewage sludge mixture aerobic by the diffusion of compressed air through the bottom of the aeration tank by mechanical agitation such as produced by paddles, or the cascade method of aeration. (See Fig. 15)

3) Equipment for separating the sludge from the liquor, for returning the sludge to the aeration tanks, for discharging excess activated sludge, and in some cases for the re-aeration of returned activated sludge.

4) Automatic timing equipment for intermittent aeration, installations for utilization of produced gas (motors), etc.

Activated sludge is separated from the liquor by plain sedimentation, the detention period being around 2 hours. Detention periods that are too long cause deterioration of the biological floc, therefore, the sludge should be removed as soon as possible after settling. Excess activated sludge, usually amounting to 1. 5% - 2. 5% of the sewage flow (the lower figure being for normal domestic sewage) is disposed of by dewatering and drying. It is then made into fertilizer, or is incinerated, or is otherwise disposed of.

The effectiveness of removal of suspended solids and B. O. D. by the activated sludge is between 85% and 95%, and of removal of bacteria is 90% - 98%.

Advantages of the activated sludge system:

1) Produces a clear, sparkling, and non-putrescible effluent.

2) Produces no odor during the operation.

3) The degree of nitrification is controllable between limits.

4) The effluent produced can be varied in accordance to the character of the diluting water available.

5) More than 90% of the bacteria and almost as much of the B. O. D. is removable.

6) The installation cost is low.

7) The value of activated sludge in the manufacture of fertilizer.

Disadvantages of the activated sludge system:

1) Lack of complete understanding of the dynamics of the process so as to allow complete predictable control under all conditions.

2) Difficulties in preventing the loss of activity of the floc and the bulking of the sludge.

3) Its great sensitivity to changes in quality of influent.

4) The difficulties in dewatering and disposing of the large quantities of sludge produced.

5) Because of the above conditions there is need of constant and highly skilled attendance For this reason the system is not recommended for small communities.

6) The operation costs are high.

7) To these disadvantages may be added the condition of foaming in the aeration tanks caused by the universal use of detergents.

Aerobic Digestion (Fig. 2)

Although it has long been known that sewage can be oxidized to an ash of very little bulk by diffusing sufficient air through it or by surface absorption of air for a sufficiently long period of time (the activated sludge being a partial application of this aerobic digestion principle,) it is only within recent years that this principle has been more pointedly applied. This process tends to simplify the sewage treatment technique, and has been applied more successfully for units of smaller capacities such as for schools and subdivisions. This process, although still in the experimental stage, is described here because its potentialities appear to be worthwhile. Aerobic digestion has also been called "rated aeration", "super aeration", "wet combustion", and "total oxidation".

The diffusion of air through the liquid sewage may be accomplished by various techniques, the principal ones being:

1. By blowing air from diffusers at the bottom of the aeration tank into the circulating liquid contents of the tank.

2. By drawing outside air down a hollow shaft which disperses it throughout the contents of the aeration tank through a rotor at the lower end of the shaft.

3. By an open end up-draft tube centered in the aeration tank which keeps lifting the bottom layers of the liquid to the surface, causing a continuous replacement of the top layer and thereby allowing surface absorption of oxygen by the whole contents of the tank.

For illustrative purposes, the blower type will be described below:

The Principal Items of Equipment: These include a bar screen, comminutor or similar cutting device, an aeration tank, air diffuser and blower, final settling tank, effluent trough and the necessary motors and controls, piping and wiring, and regulating valves. Some of these may be omitted, depending upon the technical arrangement used.

Description of the Process: The process begins with the sewage passing into and through the inlet box which is located in one side of the aeration tank. Where two or more treatment units are operated in parallel, a division or distribution box should be provided. The inlet box directs the sewage into an inlet manifold or flume. The manifold has a hopper bottom with slot opening at the bottom to distribute and disperse the incoming sewage in the aeration tank. .A bar screen extending along the manifold removes any unusually large solids from the raw sewage as it enters the plant. The bar screen should be constructed to permit easy cleaning by raking from above. It should have an overflow weir at the end to permit sewage to enter the plant in case the screen becomes clogged. A baffle below the inlet slot deflects aeration tank liquor away from the inlet port.

A sewage solids comminuting machine may be provided at the inlet which is capable of cutting, shredding or grinding the sewage solids to a size which will pass through a 1/4" diameter opening.

The sewage then flows directly into an aeration tank which is the heart of the system. This tank should provide at least 24 hours detention of the full design flow, and should be provided with baffles where necessary to insure rapid circular flow without dead spots where sewage solids may accumulate and become septic. A water spray system may be provided for control of foam or froth in the aeration tank.

The aeration tank is usually rectangular, provided with an air distribution manifold or air diffuser near the bottom and directly beneath the inlet port. Sufficient orifices should be provided in the top face of the manifold to insure uniform small bubble distribution of the air at the total rated capacity of the blowers over the entire width of the basin. The air is usually forced in by a rotary or centrifugal air compressor. It may be advisable to recommend two air compressors. A speed control device on one blower will permit variation of blower speed. Only one need be operated during periods of low demand. Because of the high design air capacity, one compressor alone will give fairly good treatment if the other should fail in service, and require repairs.

In the aeration tank, a variety of treatment activities take place at the same time and in the same tank. The turbulence produced by the excess air tends to break up the sewage solids, bringing its particles into contact with the air so that additional oxygen may be picked up. Aerobic bacteria and other living organisms present in the sewage are stimulated by activity by the abundant oxygen and proceed to digest the organic sewage solids present both in suspension and in solution. The well fed aerobic bacteria and protozoa, etc., divide and multiply their numbers. Some of the organic matter is oxidized, that is, burned at low temperature to an ash. The excess aerobic bacteria and micro-organisms are oxidized in turn to an ash.

After aeration, the sewage flows into the settling basin over the baffle or through perforations in it. The solids are returned from the bottom of the settling basin to the aeration tank for further treatment and to seed the incoming sewage with living organisms. This phase in the process may be aided by an air-lift from the bottom of the settling tank which empties the solids back into the top of the aeration tank. The effluent flows over a weir to the receiving stream. The final settling basin is generally part of the same structure as the aeration tank with only separating baffles in between. In some states a sludge storage tank may be required to receive excess sludge if any forms.

After rising through the final settling tank, the clarified liquid passes over the edges of the effluent weir trough which connects to the outlet box. A chlorinator may be required, depending on the point of discharge.

The outlet box is located on the side of the final settling tank to receive the treated effluent from the weir trough.

Aerobic digestion plants if properly designed and operated for the particular situation, produce effluents which are relatively stable and aesthetically acceptable, although, at times, unloading of solids in considerable quantity may be experienced. Because practically no aerobic digestion takes place, no odors are produced.

The plants must be protected by fencing or similar means to prevent unauthorized access or contact with the sewage by children or vandals.

Plants are available as complete-built units, each of which is suitable by itself for a small subdivision, institution, etc. For larger loadings two or more units can be run in parallel. When two or more treatment units are operated in parallel, a junction box should be provided. The multiple units need not be side-by-side but may be located so as to minimize pumping. The units can be installed separately to match the growth of demand as additional houses are built.

Sludge Digestion

Sludge produced by settling, chemical treatment, and oxidation devices can, after digestion, be disposed of by various methods including drying, burning, lagooning, land filling, fertilizing, and dumping into the sea. The primary purpose of sludge digestion is to produce an innocuous residue which can be disposed of easily. Digestion is accomplished mostly by anaerobic action. The intermediate products formed include compounds of nitrogen, carbon, sulfur and phosphorus. The end products are mainly humus-like residue, salts (the most important of which is ammonium carbonate), and such gases as methane, carbon dioxide, hydrogen sulfide, and sometimes hydrogen.

Sludge digestion passes through 3 stages, all three of which occur simultaneously under normal operating conditions, but under natural conditions these stages may be demonstrated to follow in sequence by examining the changes that occur in the pH value of the sludge liquor and the rate of gas production. (Fig. 110) The method of operation determines which stage will predominate. The progress of sludge digestion can be measured by the volume and type of gas produced, the reaction of the liquor, the reduction in volatile matter, and the drainability of the residue. The three stages are:

1) Acidification: A period of intensive acid production. Carbohydrates and soluble nitrogenous compounds are attacked and a large amount of carbon dioxide is produced. Insufficient seeding with "ripe" sludge or low temperature conditions result in the accumulation of acidic intermediate decomposition products and in the retardation of gasification. Lime must then be added to neutralize the acidic material in the digestion tank. The average pH in this stage is 6.8 to 5.1.

2) Acid regression: A period of decreased acid production, and digestion of organic acids and nitrogenous compounds combined with liquefaction. In this period there is only a small gas production, and amines are formed by the enzyme action of bacteria. The pH rises to between 6.6 and 6.8.

3) Gasification: A period of intensive digestion of the more resistant materials (proteins and amino acids) and stabilization by spore-forming anaerobes and fat-splitting organisms. When digestion is effective, the gasification stage predominates. The gas in this period consists largely of methane. The pH rises to between 6.9 and 7.4. Seeding and increasing the temperature will speed up the rate of gas production many times. The optimum medium temperature for digestion is between 80° F. and 90°F., preferably about 85°F.

Domestic sewage solids produce about 0.8 cubic feet of gas per capita per day. At optimum temperature conditions, the quantity of gas is about 12 cubic feet per pound of volatile matter. The carbon dioxide in the gas varies from 15 to 35%, and is affected by the degree of digestion and types of waste present.

Digested sludge will show an average of 1.5 to 2.0% nitrogen, 0.3 to 1.5% phosphoric acid, and no potash.

Advantages of sludge-digestion:

1) It eliminates the nuisance character of sludge.
2) It preserves to some extent the soil enrichment value of sludge. The sludge can be used to increase the humus content of the soil, to improve the soil structure, and to increase the water holding capacity of the soil.
3) It produces enough combustible gas to be of economic value. The fuel value of fresh, chemically coagulated sludge is ordinarily about 600 to 650 B. T. U. per cubic foot and from 500 to 650 B. T. U. per capita per day.

Disadvantages of Sludge-digestion:

1) High cost of equipment
2) Skill required for maintaining operation.

Unsatisfactory digestion is indicated by the presence of hydrogen sulphide, skatol, mercaptan, and other foul substances, mere traces of which will impart intense, characteristic, highly offensive odors. Lime is commonly used in such cases, also when the digester is placed into operation, to raise the pH to the optimum value. The most desirable temperature for effective digestion is 85°F., as stated; for this reason the produced gas is often used in water heaters circulating heated water through coils placed in the digesters.

Preparation for Sludge Disposal

Theory of Sludge Production and Handling

Drying. The most common method of removing water from sludge is by drying on sand beds usually composed of 12 inches sand on 6 to 8 inches graded gravel and underdrained with

transverse lines of open joint tile spaced 8 to 10 feet apart and connected to a main. Uncovered sand beds vary from 1 to 3 and more square feet per capita, depending upon type of treatment employed, rainfall, and climate. Glass covered beds increase the efficiency of sludge drying about 35%. The solids content of bed-dried digested sludge is about 40% by weight and its volume about 1/2 of that of the wet sludge. Likewise sludge drying can be accelerated by the addition of alum which causes the sludge layer to crack.

Vacuum Filters usually consist of large copper mesh drums covered with filter cloth and revolve horizontally. These machines can convert liquid sludge into a readily handled cake form at a rate of 3 to 10 pounds of dry solids per square foot of filter area per hour. The moisture content of the sludge will normally vary from 65 to 80%. The filtrate obtained from this process usually is returned to the raw sewage. In order to produce a satisfactory rate of filtration, it is necessary to increase the size of the sludge particles by one or a combination of three methods, i.e., acidification, addition of coagulants, and heating of the sludge. The pretreatment of digested sludge by washing prior to conditioning is known as elutriation. Elutriation is accomplished by mixing water with sludge at a ratio of 2:1 for about 10 minutes, allowing the mixture to settle, and drawing off the supernatant liquor which is returned to the sewers. This process can reduce the amount of ferric chloride used by 50%, will lower the ash content in the filter cake, and eliminates the use of lime during conditioning.

Centrifuges. High speed centrifuges are being tried in some places. They produce a cake which contains 55 to 75% moisture, and an effluent high in finely divided suspended solids (35 to 55% of the original sludge solids) and high in B.O.D.

Heat Dryers. In order to reduce the water content of sludge to 10% or less, as is required when sludge is to be transported or manufactured into fertilizer, it becomes necessary to use direct or indirect heat dryers or spray dryers. The heat dryer consists of a revolving cylinder into which moist sludge is fed. The heat in contact with the drying sludge should not exceed 700° F. The escaping hot gases can be prevented from creating a nuisance by raising the gases to a temperature above 1200° F.

Spray Dryers. This consists of spraying wet sludge into a "hot tower" down which a current of hot gas is passing. The evaporated water passes off with the hot gases and the dried solids settle at the bottom of the tower. This method, however, presents difficulties.

Incineration. After sludge has been dewatered to a moisture of 80% or less, it may be mixed with garbage and rubbish and burned in an incinerator. Likewise, multiple hearth furnaces and special incinerators in which heat drying is the first stage of sludge incineration have been constructed for this purpose.

Volume-Moisture Relations: Sludges consist of a mixture of phases, with water usually the dominant constituent. Generally, the mixture may be considered to consist of a liquid phase and a solid phase; however, sludges may be composed of mixtures of liquid phases, or mixtures of liquid phases plus a solid phase. The volume of a given mass of sludge is the sum of the volumes of the phases comprising it, as illustrated below for a solids-water sludge.

$$\text{Volume Sludge} = \text{Volume of Suspended Solids} + \text{Volume of Water}^*$$

$$= \frac{\text{Weight of Suspended Solids}}{\text{Specific Wt. of Suspended Solids}} + \frac{\text{Weight of Water}}{\text{Specific Wt. of Water}}$$

When water is overwhelmingly the dominant fraction, as is usually the case, the following approximate expression describes the relation between sludge suspended solids concentration and sludge volume for a given mass of suspended solids.

$$\frac{(\text{Volume})_1}{(\text{Volume})_2} = \frac{(\text{Suspended Solids})_2}{(\text{Suspended Solids})_1}$$

*Volume of water is assumed to be equal to volume of aqueous solution.

The volume of sludge to be handled is halved by a doubling of the suspended solids concentration. The difference in volume is due to the release of water. Therefore, it is small wonder that virtually all sludge handling practices involve separation of water to minimize the volume to be sent to disposal.

Control of Sludge Properties: The solids fraction of sludges from chemical treatment may be crystalline or amorphous in structure, with mixtures not uncommon. The objective in the control of sludge properties by process adjustment is the formation of a sludge with a dense, granular structure as opposed to a hydrous gel structure. The desired sludge would separate in compact volumes and would readily release its pore moisture during filtration. With crystalline precipitates, the techniques employed in the process industries for adjustment of crystal size may be adapted to control of sludge properties. Prime factors affecting crystallization are supersaturation, nucleation, temperature, growth surface area and deposition rate. The size of crystals is a function of the number of nucleation sites available and the degree of supersaturation. Highly supersaturated solutions tend to produce showers of tiny crystal nuclei. To achieve the large crystals desired for optimum sludge properties, the addition of seed nuclei in the form of return sludge is desirable, and the rate of addition of reagents should be balanced against the rate of deposition on the seed crystals. Temperature adjustment can effect profound changes in sludge properties due to its effect on reaction rates, viscosity, and possible effect on crystal structure. Each crystal system has unique characteristics and behavior. In some cases the practical range of supersaturation is wide, while in other cases a small degree of supersaturation may induce spontaneous precipitation.

Amorphous sludges may range in structure from granular particles of uniform size to non-homogenous masses composed of a diversity of particle sizes, shapes and composition. The overall properties of the latter structure are characteristically controlled by the presence of colloid-like fractions possessing great surface for acquisition of electric charge and hydration. Depending upon conditions, such finely divided materials may differ in structure from an impervious gel-like mass to a porous mixture of aggregates. The energy required for the dewatering of gels is normally many times that required for the dewatering of aggregates. With amorphous sludges, it is infrequent that process conditions can be formulated from theoretical considerations to yield optimum sludge properties; however experimental investigation of the following variables may yield attractive dividends: 1. temperature; 2. pH, 3. chemical agents employed in the process, 4. rate of agitation, 5. presence of precipitation nuclei, 6. order and rate of addition of chemical agents.

Sludge Conditioning: The treatment of liquid sludges to improve dewatering properties is termed "sludge conditioning". The mechanism involved is the removal of or transformation of impervious gels and fines into porous aggregates. Elutriation, the washing of sludge to remove fines, chemical dispersants, and chemical agents possessing a coagulant demand, is a simple sludge conditioning procedure. The process consists of a flash mix of sludge with water or plant effluent, followed by sedimentation to re-separate sludge from liquid.

Chemical conditioning involves the addition of coagulants to improve sludge dewatering properties by mechanisms somewhat analogous to chemical coagulation but more complex. Although all types of coagulants including multivalent metal salts, lime, and organic polymers are theoretically applicable, the dewatering properties of the precipitate formed by the conditioning agent warrants consideration as well as the coagulation efficiency.

"Filter aids" are particulate materials which when added to sludge tend to form a porous, permeable, and rigid lattice structure which retains particulates but allows passage of liquid during filtration.

Sludge Dewatering Processes: Heat treatments have been employed to effect favorable modification of sludge structure resulting in improved dewaterability. This consists of raising the wet sludge to temperatures as high as 360° F. for short periods, then decanting, followed by dewatering by filter press.

Sedimentation is the most popular method of separation of sludge. Flotation as applied to

sludge dewatering is dependent upon the attachment of gas bubbles (usually CO_2) to sludge particles (produced by addition of acid or alum, or by fermentation, preferably at 100° F. to 120° F.) until sufficient buoyancy is produced to cause the particles to float, usually after standing quiescent for 3 to 4 hours. The bubble may be precipitated on the particle from release of dissolved air, or it may be attached as a result of impact between the particle and dispersed air. Concentrated sludge is removed from the surface by collection equipment, and separated liquid is removed as underflow.

Dewatering of sludges by filtration may be accomplished by several types of equipment. Rotary vacuum filters of the drum and disk type are popular for continuous flow operation. Filter presses have been widely used for batch operations; and recently, continuous flow compression filters have been introduced which incorporate pre-thickening by tumbling or vibrating the sludge on filter media. Pressure filters have found application for the dewatering of thin sludges without prior settling or thickening.

Underdrained sand beds are effective units for the dewatering of many sludges. The mechanism of dewatering involves initially a comparatively rapid percolation of drainable water to the underdrainage system, followed by atmospheric evaporation until the sludge attains a spadable consistency. The beds are usually uncovered, although ventilated glass or plexiglass enclosures may be provided where warranted by climate or other local conditions.

Long term lagooning is a widely practiced method of dewatering sludges from industrial wastes and occasionally from domestic sewage. The process involves the discharge of sludge to a lagoon providing a long period of storage. The stored sludge undergoes gravity thickening, and the separated liquid is released as overflow. When the lagoon becomes filled with compacted sludge, it is taken out of service to allow dewatering of the contents principally by evaporation with possibly some percolation. When the stored material is dry, the lagoon is re-excavated and restored to service.

Sludge Lagoons: Lagoon lengths should be held to a maximum of 300 feet to limit localized deposition of solids, and widths of less than twice the length of the operation radius of drag line excavators to be employed in sludge removal. Dikes should be made to accommodate drag line and truck traffic.

For the design of lagoons for digested primary domestic sewage sludge, it is proposed that operation be conceived in terms of a 3-year cycle in temperate climates. The first year is devoted to the filling of the lagoons with sludge during which time it is assumed that the sludge will compact to 20 percent solids concentration. The second year is devoted to storage to allow for drying of the sludge by evaporation and transpiration. During the filling and the drying periods, any free water above the sludge layer is decanted. During the storage period (second year), net evaporation is considered to occur at a rate equal to 30 percent of the annual evaporation from a free water surface, and transpiration is considered to release an additional 6 inches of moisture per year. Evaporation and transpiration are neglected during the first year. The third year is allotted to excavation and resting of the lagoon.

Vacuum Filtration and Sludge Conditioning: By nature, domestic sewage sludges are difficult to dewater. It is by virtue of flexibility obtained from conditioning through elutriation and/or chemical treatment that vacuum filtration is feasible for such sludges. Generally, raw sludges are more easily filtered than digested sludges (trickling filter and activated). Sludge conditioning by elutriation is limited largely to digested sludges. Ferric chloride and lime are the chemical agents most commonly employed for sludge conditioning. They are normally used in combination as indicated in Table 11, but it is not unusual for them to be applied individually. Lime alone is a fairly popular conditioning treatment for raw primary sludge, and ferric chloride alone is popular for conditioning activated sludges. Very often, elutriated sludges are most economically conditioned for filtration by use of ferric chloride and lime, as indicated in Table 11, rather than by ferric chloride alone. Hydrated lime is most often employed for sludge conditioning, but for large operations the use of quicklime, slaked prior to use, may be economic. Both calcium and dolomitic limes have been successfully applied for conditioning of sludge. Some investigators have concluded that the calcium oxide fraction of the lime is the active agent for sludge conditioning.

Table 11. Chemical Conditioning of Various Types of Domestic Sludges

Type of Sludge	Chemical Dosage in Percent of Dry Sludge Solids					
	Raw		Digested		Elutriated Digested	
	$FeCl_3$	CaO	$FeCl_3$	CaO	$FeCl_3$	CaO
Primary	1-2	6-8	1.5-3.5	6-10	2-4	
Primary and Tricking Filter	2-3	6-8	1.5-3.5	6-10	2-4	
Primary and Activated	1.5-2.5	7-9	1.5-4	6-12	2-4	
Activated (alone)	4-6					

Source: Sewage Treatment Plant Design; Chemical Treatment of Sewage and Industrial Wastes, National Lime Ass.

Table 12. Properties of Common Waste Treatment Chemicals

Chemical Name, Formula and Trade Name	Molecular Weight	Common Forms and Commercial Strength	Bulk Density lbs./cu. ft.	Solubility g/100g Water degrees C.	Approx.* Market Price F.O.B. Plant
Aluminum Sulfate $Al_2(SO_4)_3 \cdot 14\ H_2O$ Alum	594.4	Tan to gray-green: powder, granules, lump, liquid — 17% Al_2O_3 minimum; 8.3% Al_2O_3	38-45 60-63 62-67	65.3 at 10 71 at 20 78.8 at 30	$45.00 per ton c.l. bags freight equalled
Calcium Carbonate $CaCO_3$ High Calcium Limestone	100.1	White or Gray: powder, granules — About 95% $CaCO_3$	100-115	0.0014 at 25	$10.50 per ton c.l. bags powder
Calcium Hydroxide $Ca(OH)_2$ High Calcium Hydrated Lime	74.1	White Powder: 72-74% as CaO	25-35	0.18 at 0 0.15 at 30 0.07 at 100	$17.25 per ton c.l. bags
Calcium Hypochlorite $Ca(OCl)_2 \cdot 4\ H_2O$	215.1	White: granules, powder or pellets 70% available chlorine	50-55	21.9 at 0 22.7 at 20 23.4 at 40	$39.50 per 100 lb. c. l. drums
Calcium Oxide CaO High Calcium Quicklime	56.1	White: lump, pebble, granule, or pulverized 93-98% CaO	55-60	Converted to $Ca(OH)_2$	$16.75 per ton c.l. bags
Chlorine Cl_2	71.0	Green-yellow gas: 99.8% Cl_2		0.98 at 10 0.57 at 30	$135.00 per ton c.l. cylinder
Dolomitic Hydrated Lime $Ca(OH)_2 \cdot MgO$	114.4	White Powder: 46-48% CaO & 33-34% MgO	25-35	0.18 at 0 0.15 at 30	$17.25 per ton c.l. bags
Dolomitic Limestone $CaCO_3 \cdot MgCO_3$	184.4	White, gray or tan: powder, granules — About 52.6% $CaCO_3$, 42.5% $MgCO_3$	105-120	0.002 at 25°	$10.50 per ton c.l. bags powder
Dolomitic Quicklime $CaO \cdot MgO$	96.4	White (light gray, tan): lump, pebble, pulverized — 55-57.5% CaO, 37.6-40.8% MgO	55-60	Converted to $Ca(OH)_2$	$16.75 per ton c.l. bags
Ferric Chloride $FeCl_3$	162.2	Anhydrous: green-black powder 96-97% $FeCl_3$ Heptahydrate: yellow-brown lump 60% $FeCl_3$ Liquid: dark brown solution 37-47% $FeCl_3$	65-70 60-64	74.4 at 0 536 at 100	$160.00 per ton c.l. drums
Ferric Sulfate $Fe_2(SO_4)_3$	399.9	Dihydrate: red-brown granules 20.5% Fe Trihydrate: red-gray granules 18.5% Fe	70-72 70-72	300 ± at 20	$38.25 per ton c.l. bags

Table 12. Properties of Common Waste Treatment Chemicals—Continued

Chemical Name, Formula and Trade Name	Molecular Weight	Common Forms and Commercial Strength		Bulk Density lbs./cu. ft.	Solubility g/100g Water degrees C. ,	Approx.* Market Price F.O.B. Plant
Ferrous Sulfate $FeSO_4 \cdot 7\ H_2O$ Copperas	278.0	Septahydrate:	green-brown granules 20% Fe	63-66	37.5 at 10 48.5 at 20 60.2 at 30	$34.50 per ton c.l. bags
Sodium Carbonate Na_2CO_3 Soda Ash	106.0	Anhydrous:	white powder 58% Na_2O	35-65	7.1 at 0 18 at 20 27.6 at 30	$37.00 per ton c.l. bags
Sodium Hydroxide NaOH Caustic Soda	40.0	Anhydrous: Liquid:	white solid or flakes 76% Na_2O 50% NaOH		42 at 0 347 at 100	$96.00 per ton c.l. drums solid 76%
Sodium Pyrosulfite $Na_2S_2O_5$ Sodium Metabisulfite	190.1	Anhydrous:	powder, 62% SO_2 20-25% SO_2	74-85	54 at 20 81.7 at 100	$110.00 per ton c.l. bags
Sulfur Dioxide SO_2	64.1	Colorless gas:	100% SO_2		16.2 at 10 7.8 at 30	$107.00 per ton c.l. cylinders
Sulfuric Acid H_2SO_4	98.1	Liquid:	60° Be'-77.7% H_2SO_4 66° Be'-93.2% H_2SO_4	106.4 114.5	 Complete	$22.35 per ton c.l. 66° tanks

* Representative 1964 price listings adapted from the Oil, Paint and Drug Reporter and Chemical and Engineering News
Solubility in terms of grams of formula in left column per 100 grams water
c.l.—carlots

Chlorination

Chlorine or chlorine compounds are added to sewage:

1) To control undesirable bacterial growth by disinfection. This includes control of pathogenic organisms as well as filamentous organisms which clog or restrict the sewage conduit or waterways.
2) To delay septic action.
3) To destroy odors.
4) To remove grease.
5) To prevent ponding of trickling filters.
6) Eliminate fly (Psychoda alternata) breeding in trickling filters.

The rate of destruction of bacteria depends on:

a) The quantity of chlorine applied. This should be enough to allow a residual of 0.2 to 0.5 p.p.m. of chlorine after the necessary contact time.

b) The chlorine demand of the sewage. This depends on the chemically reduced substances present, such as hydrogen sulphide. The greater the septicity of the sewage, the greater its reduction and the more chlorine required to oxidize it.

c) The contact time. Usually 15 to 30 minutes is sufficient to bring about efficient bacterial destruction. A residual of 0.5 p.p.m. after 15 minutes of contact is a safe average.

Typhoid bacteria are killed with lower minimum chlorine dosage than coliform organisms, therefore, efficient killing of the coliform bacteria is a good index of absence of typhoid bacilli. Chlorine residual is not obtained until enough chlorine is added to satisfy the "appetite" of the sewage. Bacterial destruction begins before residual chlorine appears and increases toward the maximum as the residual appears. The difference between inhibition of

growth of bacteria and disinfection is one of concentration of chemical. There may be inhibition of growth at low concentration and disinfection at high concentrations. When bacteria are not definitely killed they may give "after growths" after the influence of the chemical agent is removed. Except when 100% of the chlorine demand is satisfied, growth increases 6 hours after chlorination, but does not reach the original numbers until after 24 hours. Several factors advanced to explain this are:

1) Protozoa are killed by the chlorine more readily than bacteria, thus allowing the remaining bacteria to multiply more rapidly.

2) The after growth is due to the development of chlorine-resistant bacteria.

The type of chlorinator most commonly used is one which receives the chlorine from a cylinder into the vacuum chamber of the chlorinator. It is measured by an orifice meter or a rotameter (spinning top indicator) and drawn into an injector where it mixes with water. The chlorine solution is then carried by a rubber hose to the point of application. The chlorine and sewage must be thoroughly mixed. The maximum amount of chlorine which can be dissolved satisfactorily in sewage by diffusion is less than 3.5 p.p.m.

Efficiency of Various Treatment Processes

The relative sanitary efficiency of various processes employed in sewage treatment are:

Process	% of Removal of Bacteria
1) Coarse screens	0 to 5
2) Fine screens	10 to 20
3) Grit chambers	10 to 25
4) Sedimentation	25 to 75
5) Septic sedimentation	25 to 75
6) Chemical precipitation	40 to 80
7) Contact beds	About 80
8) Trickling filters	90 to 95
9) Activated sludge process	90 to 98
10) Intermittent sand filters	95 to 98
11) Broad irrigation	97 to 99
12) Disinfection of raw or settled sewage	90 to 95
13) Disinfection of filter effluents	98 to 99

Typical Imhoff Tank, Sewage Treatment Plant Installation (See Fig. 14)

1) Imhoff Tank. The Imhoff tank, like the septic tank, combines sedimentation with sludge digestion. There is, however, an important difference: digestion takes place in a separate compartment from that where sedimentation occurs. The sludge compartments of Imhoff tanks in Southern locations should have approximately the same capacity volume as that used for unheated separate sludge digestion tanks, which is 3.0 cu.ft. per capita. The sludge capacity should be computed from a line 18 in. below the slot. Since there is no intimate contact in the Imhoff tank between the incoming sewage and the digested sludge, a better effluent is obtained. The gasses in septic tanks which, in rising, inhibit the settling of the sludge,are diverted by the sloping walls forming the bottom of the sedimentation compartments in the Imhoff tank. The sedimentation compartment of the Imhoff tank is usually designed for a velocity which will not exceed 1 ft. per minute at peak flows. The retention periods in the sedimentation chamber is 2 - 3 hours at average flow. Sludge is drawn off by gravity every 30 to 45 days from the sludge compartment by means of a sludge draw-off-line.

2) Dosing Tank. In the smaller installations a dosing tank is usually provided to discharge sewage intermittently to the secondary treatment system. These dosing tanks are usually designed so that they will operate for a 10 minute period and provide a rest period of about 20 minutes. Automatic siphon equipment regulates the dosing operation. (Fig. 17)

3) Rotary Trickling Filters. Low capacity trickling filters are very frequently used on the smaller sewage treatment plants. These filters usually provide a biochemical oxygen demand reduction of 85% to 95%. The low capacity filters are designed for loadings not to exceed 600 lbs. per day of applied B.O.D. per acre foot or 2.5 m.g.d. per acre of bed. The filters should not be greater than 6 ft. in depth.

4) Final Settling Tank. Final sedimentation tanks are usually provided for treatment plants where trickling filters are used. These tanks have a retention period of approximately 2 hours. The tanks can either be provided with mechanical scrapers to remove the sludge to a hopper in the bottom, or the tanks can have a steep slope so that the sludge can be drawn off by gravity through the sludge draw-off-line. In the latter, the slope is usually about 45 degrees or over. Sludge is usually drawn from the tanks 2 or 3 times during each day. The sludge that is drawn off is returned to the pump sump, hence to the inlet end of the Imhoff tank. The final effluent from the settling tank is discharged to the stream after being chlorinated.

5) Chlorination. Chlorination is usually of the 3 point type. Chlorine is applied to the inlet end of the Imhoff tank, to the dosing tank, and to the effluent of the final settling tank. The first two points of application are used for odor and algae control and the last point is for sterilization. In chlorinating for odor control, it is essential that chlorine be applied only in amounts to neutralize the objectionable odors. However, up to 15 p.p.m. of chlorine may be added normally to raw sewage. No residual chlorine should be maintained. In chlorination for sterilization, a residual chlorine of about 0.2 parts per million should be maintained.

6) Sludge Drying Beds. The sludge that is drawn from the Imhoff tank is discharged on to sludge drying beds. Open sludge drying beds consist of about 12 in. of sand and 6 in. of graded gravel. The beds are provided with an underdrain system. Not less than 1.5 sq. ft. of bed surface per capita should be provided. During rainy seasons, it is frequently found that great difficulty is experienced in drying sludge. In order to accelerate the drying, alum is frequently found to be helpful if applied to the sludge as it is discharged on to the beds. Glass covered drying beds may reduce the required drying area by 25 to 50%.

Typical Activated Sludge Plant Installation (See Fig. 15).

1) Primary Settling Tank. The primary settling tank in an activated sludge plant installation is designed for a retention period of 1 1/2 hours. The tanks are usually provided with mechanical sludge collectors used to move the sludge to a hopper. The sludge collecting device is of the endless chain type and is usually arranged so that the sludge is moved to the hopper at the bottom while, at the same time, the endless chain skims the floating materials from the surface of the liquid. The surface skimmings are discharged into a trough at the opposite end of the tank where the sludge is collected. Two or three times during the day the sludge is drawn from the primary settling tank and skimmings collected in the trough are removed.

2) Aeration Tank. Aeration is provided either by means of compressed diffused air or by mechanical devices. When compressed air is used the retention period is approximately 4 - 8 hours. When mechanical devices are used, the retention period is 8 - 12 hours. When compressed diffused air is used, the rate of application is approximately 0.2 - 1.5 cu. ft. of free air per gallon of domestic sewage treated.

3) Final Settling Tank. The construction of the final settling tank is a great deal similar to the primary settling tank, but the retention period is longer, 1 1/2 - 2 1/2 hours. Scraping devices are provided on the bottom to remove the sludge to the hopper. Skimming devices are not used on these tanks as very little floating material is obtained if the aeration be held between the proper boundaries and loss of sludge activity be avoided. A proportion of the sludge collected in this final settling tank is returned to the inlet end of the aeration tank. This sludge is known as "Activated sludge". The return flow is approximately 15 to 25% of the flow in the primary sedimentation tank. The effluent from the final settling tank is removed by means of a weir and discharged after chlorination to the stream.

4) Chlorination. Provisions are usually made for three point chlorination. Provisions should be made to chlorinate either the raw sewage entering the primary settling tank, the effluent from the primary settling tank, or the effluent from the final settling tank. The first two points are provided for odor control and the last point for sterilization. In chlorination for odor control, sufficient amount of chlorine should be added only to neutralize the odors. A residual chlorine content should not be maintained. For sterilization a residual content of about 0.2. p.p.m. should be maintained.

5) Digestion. The sludge withdrawn from the primary settling tank, and the surplus sludge from the final settling tank are discharged to the digestion tank. When heating facilities are used in the digestion tank, a capacity of 4.0 cu. ft. per capita should be provided. When the digestion tank is unheated, a storage capacity of 6.0 cu. ft. per capita should be provided. Heated digestion is usually maintained at a temperature of 90 degrees Fahrenheit. Some tanks are provided with floating covers where the gases generated from the digestion processes are collected. These gases are used to operate sludge pumps, air compressors, and other units of the plant. The supernatant or top liquor from the digestion tank is returned to the inlet end of the primary settling tank.

6) Sludge Bed. Sludge is withdrawn from the digestor every 30 to 45 days. This sludge is discharged on to sludge beds. The sludge beds are constructed similarly to those used for Imhoff tanks. Sludge is drawn usually to a depth of about 10 inches in each bed, and the beds are cleaned and raked before being used again.

Interpretation of Sewage, Sludge, and Effluent Analysis.

The Sampling Problem. Proper sampling of sewage influent to a treatment plant is difficult due to:

1) Variation from hour to hour. Representative samples may be obtained by compositing sub-samples taken hourly, including samples at night, in proportion to the flow. Where the flow is metered (venturi meter, triangular weir, or Parshall flume, Fig. 13), this procedure is relatively simple; where no meter is available, approximate flow figures can be obtained by timing the pumping period of the pump delivering the sewage to the primary settling basin with allowances for recirculation if present. In large plants, automatic sampling and proportioning devices have been developed. It should be mentioned that composite samples cannot be used for the determination of dissolved oxygen.

2) Coarseness of part of the suspended solids, and lack of uniformity of sewage in various parts of a flow channel. These factors will affect such tests as suspended solids, settleable solids, turbidity, and B.O.D. Satisfactory samples are, therefore, best secured at points where there is agitation, such as, at exits of pumps, comminutors, flocculators, and in channels where there is agitation.

Because the hour to hour variation of effluents is less than influents, and the coarse material has been removed, sampling is less difficult. In this case, samples composited from 2-hourly sub-samples, instead of hourly, are sufficient. Night sub-samples should be included.

Sampling of primary sludge for measuring the solids (or moisture) is very difficult since sub-samples must be taken almost minutely in order to be representative. This, therefore, is impractical. Taking samples for volatile solids determination can be satisfactory if care be taken. Activated and digested sludges are usually more uniform than primary sludge and significant samples for moisture content may be secured with ordinary care.

All samples of sewage and effluent should be preserved by icing in order to protect against bacterial changes in the sample bottle.

The Importance of Analysis

Sewage and effluent analyses are made in order to:

1) Give information on the strength, character, and conditions of sewage to aid in the selection of treatment and disposal methods, and to act as an indispensable guide for the plant operator.

2) Measure and explain the performance of sewage treatment works.

3) Interpret and predict the behavior of waters into which sewage is discharged.

4) Assist in future designing of the plant.

5) Establish records which are a valuable source of information for community and state. In many states laboratory control is required by law.

Even though the sanitarian may not be an engineer and therefore not expertly acquainted with the technical aspects of the design of sewage treatment plants, he should understand the criteria which indicate the adequate or inadequate functioning of such plants. The criteria are manifested to a large degree by laboratory analysis of the sewage or effluent. A complete evaluation of the

results of analysis will not be attempted here. But a study of the fundamentals of sewage control as outlined here will answer a good number of questions arising from the examination of sewage analysis.

The question may arise that since the testing is done by plant operators and official public health engineers, why should the sanitarian have a working knowledge of these matters. The answer is again, that a well informed local sanitarian can be an invaluable aid to the public health engineering staff which usually does not inspect a plant more than once or twice a year and is only called in when something goes wrong. A timely notice from the sanitarian to the engineering office, based upon a proper understanding of local conditions, can often prevent a waste of time and money and prevent the creation of health hazards for the community.

Laboratory tests may or may not give the operator the information he desires when faced with certain problems. Moreover, operators of long experience often know how to interpret certain visual evidence of sewage conditions. This has lead to criticism of laboratory tests. The reasons for such criticism are:

1) Erroneous results due to improper sampling.
2) Erroneous results due to improper test techniques.
3) Unwise selection of tests.
4) Needless routine repetition of tests of little value.
5) Failures due to deteriorated chemicals, etc.
6) Faulty interpretation of correct results.

To avoid the faults of poorly chosen special tests, and of wasted time on routine tests which are of slight value, the significance and purpose of various tests should be known. Every plant should have a schedule of routine tests and a list of tests to be used in special investigation.

Tests

A number of tests are important for the proper control of a sewage treatment plant. The tests required will vary with the size and character of the plant and the local conditions. It can be stated that all small plants should perform at least three tests daily:

1) pH tests on raw and settled sewage and on the final effluent.
2) Settleable solids tests on raw and settled sewage and on the final effluent.
3) Relative stability test on the final effluent. For activated sludge plants it is desirable to measure also the temperature of the raw sewage, the dissolved oxygen, suspended solids, and settleable solids for each aerator, and either the relative stability or the B. O. D. for the final effluent. For separate clarifier-trickling filter plants it is desirable to measure the efficiency of the various units.

Appearance and Odor. Normal fresh sewage is almost odorless unless mixed with particular types of industrial waste. A variation from the normal should be investigated. Stale or septic sewage should be investigated to determine the cause. Odors of gasoline or dry-cleaning solvents should be observed lest explosion hazards develop, and the source discovered and eliminated.

The normal color of fresh sewage is gray unless mixed with particular types of wastes. For instance, creamery wastes may render the sewage almost white; wastes from slaughtering houses in the sewage may make it appear yellowish brown, etc.

Turbidity. This test is especially useful in determining the relative degree of clarification of effluents or the approximate suspended solid content.

Temperature. Temperature testing is important for large plants but for small plants using Imhoff tanks it need not be done routinely. Occasional tests taken regularly during the various seasons are in that case sufficient to give the temperature history. The temperature is important because it influences sedimentation percolation, viscosity, dissolved oxygen, chemical reaction rate, and bacterial growth.

The activity of living organisms and chemical precipitation are sensitive to pH, alkalinity and acidity.

pH is recommended as a routine test on sewage to provide information explaining variations in plant behavior and in detecting industrial wastes. pH tests on digesting sludge should not be used routinely if the function of the digesting tank be normal. It should be used where sludge is being treated with lime to start digestion, and when foul odors develop and sludge appears to be digesting poorly. The pH of the liquor in a digesting tank is rarely above 7.4.

Settleable Solids. This is a simple and reliable test of efficiency for plain sedimentation installations. It is a routine test and should preferably be made of composited samples. This test and the quantity of sewage will indicate the amount of sludge collected at the plant which enables the operator to calculate the primary settling tank efficiency and the amount of sludge that must be digested or dewatered.

Suspended Solids. This is a fairly good test for determining the relative degree of clarification of effluents. In this test and that for settleable solids, unless the plant be equipped with a comminutor, inaccuracies may arise from failing to consider the 5 to 10% of the suspended solids too large to be caught in the samples. Therefore, estimations of the expected sludge to be removed can only be approximately calculated.

Dissolved Solids. This test determines the amount of dissolved and colloidal matter removed by biological oxidation processes. The test is subject to inaccurracies and, therfore, day-to-day variation should not be considered significant; only averages of a week or a month are significant.

B. O. D. If this test be made with care, the results are valuable in revealing day-to-day variations in the efficiency of a plant, or as an aid in comparing similar types of plants. It should not be used as a sole criterion for comparing plants of different types, nor for testing industrial wastes. It measures the amount of decomposable matter and the nuisance level of sewage. In 5 days at 20° C. (the time-temperature elements of the test), it is practically only the carbonaceous matter that has undergone decomposition. This test is displacing the "nitrogen" and "oxygen consumed" tests. It indicates the oxygen consuming capacity of the sewage and the load placed on the oxidizing units. The demand on the oxidizing units is that of the raw sewage less the reduction accomplished in the primary settling units. The test has the disadvantage that sudden changes in B. O. D. detected after 5 days, refer to conditions having existed five days previously and often no longer present. This makes the prompt taking of corrective measures often impossible.

Oxygen Consumed. This test may be used as a rapid test in measuring sewage or effluent concentration, in estimating the industrial carbonaceous matter in sewage, and in evaluating the performance of various steps in treatment, but is not capable of broad interpretations in sewage treatment as a whole, or in the self-purification of receiving streams. The usual test is that for oxygen consumed from permanganate in acid solution. There is also an instrument named the odeometer which measures the consumption of oxygen per hour by a sample of sewage.

Relative Stability. This test is, in part, a measure of the pollution remaining in an effluent, and, in part, a measure of the "condition" relative to the supply of oxygen. (Relative Stability means the percent ratio of the oxygen available to the oxygen required to satisfy the first stage B. O. D. The first stage of B. O. D. is the p. p. m. of oxygen needed to oxidize the carbonaceous organic matter in the sewage without decomposition of nitrogenous substances.) If nitrification be established, relative stability loses its numerical significance.

Dissolved Oxygen. This test is very valuable for gaining information about plant operation by testing the effluent of a sewage treatment plant or the mixed liquor of activated sludge processes. The activated sludge process functions efficiently when the oxygen content in the final clarifier is 1 to 2 p. p. m. When the oxygen content rises above 4 p. p. m. the air supply should be cut down to avoid surfacing of sludge in the secondary sedimentation tanks and to conserve power. If the dissolved oxygen gets low and the air cannot be increased, then it is necessary to cut down the circulating load of the activated sludge rather than allow it to become septic. An adequate supply of oxygen keeps the sewage or the sludge fresh. Stale sewage results from a recent loss of oxygen. Special care is required in taking samples. Samples should be dipped from final clarifier or secondary sedimentation tank, rather than from a flume or pipe after the effluent has tumbled over a weir. Samples can also be made at various points in the aeration tank. All samples must

be put to test promptly after they are taken. Sampling should preferably be done with special sampling apparatus making possible a 3 time displacement of the sewage in the sampling bottle to avoid the error of absorption of oxygen during sampling.

Nitrites and Nitrates. Well oxidized effluents, whether from activated sludge or trickling filters, contain nitrites and nitrates and indicate that the nitrification process is behaving efficiently.

Sludge Concentration and Density. This is an important test for control purposes in activated sludge plants. The actual sludge concentration can be determined only by measurements of suspended solids by weight.

Solids Content. This test provides a basis for judging whether sludge is being removed in concentrations that are adequate and economical. It should be realized that the solids content greatly affects the volume of sludge. With a specific gravity close to one, a sludge with 5% solids will have double the volume of a sludge having a 10% solid content. The solid content for the same type of sludge will vary greatly with the time allowed for settling and with the amount of digestion. Therefore, fresh sludge will have a minimum solid content and settled digested sludge a maximum solid content. For fresh sludge from primary sedimentation tanks, a solid content of 2.5% is adequate; after removal of excess water the content may rise to 5%; whereas that of wet digested sludge may be as high as 13%. Fresh pumped excess activated sludge will have a solid content of about 0.7%; after 1 hour standing 1.5%; and digested activated sludge 2.5%. Wet digested mixed sludge (primary and excess activated) may have 7% solids content.

Percent Organic or Volatile Solids. The chief use of this test made on fresh and on digested sludge is to calculate the % destruction of the organic matter in the digestion process. The ratio between organic matter in fresh and digested sludge indicates how much organic matter has been digested; for example, when a sludge with 3 parts organic matter and 1 part ash is changed to 1 1/2 parts organic matter to 1 part ash, it indicates that 50% of the organic matter has been digested. It is this ratio that is significant in estimating the efficiency of the digesting process. This test is also important in judging the fertilizer value of the sludge. The nitrogen content of dry digested sludge is approximately 2 to 6% of the organic matter percentage. Therefore a sludge with 50% organic matter may be expected to have about 1 to 3% nitrogen. Although useful in sludge analysis, this test is too inaccurate to be used routinely in sewage analysis.

Of the organic matter in average sewage, about 40% is composed of nitrogenous substances, 50% of carbohydrates, and 10% of fats. On a dry basis, the nitrogen content may vary from 0.8% to about 6.0% according to the process used.

Other tests that may be useful and are sometimes performed are Chloride, Sulphide, Chlorine Demand, Ash of Suspended Solids, Organic Carbon, Solids Content, Percent Organic or Volatile Solids, Grease, Bacterial, Screenings, Grit and Scum.

Since the tests for pH, settleable solids, and relative stability should be performed routinely in small sewage disposal plants where the sanitarians watchfulness is more important than in large plants, these tests will be described.

Hydrogen-ion Concentration or pH Test. This is the same as described in chapter on Public Water Supply.

Settleable Solids (By Volume). Fill an Imhoff cone to the liter mark with a thoroughly mixed sample. Settle for 0.75 hour, gently stir the sides of the cone with a rod or by spinning, settle 0.25 hour longer and record the ml. of settleable solids in the cone.

Settleable Solids (By Weight). Determine the suspended solids in a sample of the sewage as subsequently described, then pour a well mixed sewage sample into a glass vessel not less than 9 cm. in diameter, using a quantity of sample not less than 1 liter but sufficient to insure a depth of 20 cm. A glass vessel of greater diameter and larger volume of sample may be used. Allow to stand for one hour (the use of the theoretical detention period of the plant settling unit is permissible if desired). Without disturbing the settled material or that which may be floating, remove 250 ml. of the sample from the center of the container at a point half-way between the surface of the settled sludge and the liquid surface. Determine the suspended solids of this super-

natant liquor. This value in p.p.m. is equivalent to the non-settleable solids. Calculation: p.p.m. by weight of settleable solids = p.p.m. suspended solids minus p.p.m. non-settleable solids. It will be noted that the method of settleable solids by weight includes also that matter which would float to the top of the container and which would be left out in settleable solids by volume.

Relative Stability of Effluents. The use of this determination is rapidly decreasing, as it is being replaced by the more exact determination of dissolved oxygen, nitrite, nitrate and biochemical oxygen demand. However, for small plants with limited laboratory facilities the stability towards methylene blue fulfills a very useful service in indicating the satisfactory operation of the biological oxidation processes.

Fill a 150 ml. glass stoppered bottle with sample, avoiding aeration. Add exactly 0.4 ml. of a 500 p.p.m. methylene blue indicator solution below the surface of the liquid and mix by inverting the bottle. Incubate at 20° C. with a water seal, observing the samples daily until decolorization takes place. Report the days required for decolorization, or if preferred, the relative stability percentage shown in the table below. If other sized incubation bottles be used, a proportional amount of the indicator solution must be used. As this test depends on bacterial action, bactericidal substances should be neutralized or removed (as too high alkalinity or acidity and free chlorine.) If this be not possible, the test is inapplicable. After correction, the sample should be seeded with sewage bacteria.

It may be noted here that test for alkalinity and acidity are the same as described in chapter on Public Water Supplies.

Table 13. Relative Stability Numbers

Time required for Decolorization at 20° C.	Relative Stability S.	Time required for Decolorization at 20° C.	Relative Stability S.
Days	Percentage	Days	Percentage
0.5	11	8.0	84
1.0	21	9.0	87
1.5	30	10.0	90
2.0	37	11.0	92
2.5	44	12.0	94
3.0	50	13.0	95
4.0	60	14.0	96
5.0	68	16.0	97
6.0	75	18.0	98
7.0	80	20.0	99

If the samples be incubated at 37° C., the number of days are reduced 50% for the same percentage.

The test for the biochemical oxygen demand is not only a required test in activated sludge plants but also in survey work on stream pollution where the sanitarian may be required to function. This test will therefore be described.

Biochemical Oxygen Demand. (B.O.D.) (for unchlorinated sewage and effluents). This test is determined by making several dilutions of the prepared sample in order to cover the range of depletions expected (usually 0.1 to 1.0% of strong trade wastes; 1 to 5% of normal and settled sewage; 5 to 25% of oxidized effluents; and 25 to 100% of polluted river waters). The sample should be adjusted to about a pH of 7.0 with dilute acid or sodium carbonate. The dilutions of the sample are made with buffered distilled water saturated with dissolved oxygen since the dilution water should have no appreciable oxygen demand of its own or contain germicidal substances. In making dilutions, care is taken not to aerate the liquid by vigorous shaking although it must be carefully mixed. The diluted sample is placed in 250 to 300 ml. glass stoppered bottles which are filled to capacity without leaving an air bubble. A bottle called the blank, is filled with dilution water alone. The 5 day oxygen consumption of the blank should not exceed 0.2 p.p.m. The blank and the diluted samples are incubated for 5 days at 20° C., after which the dissolved oxygen is determined on all the samples and the blank, using the sodium azide modification of the Winkler Method. Those dilutions showing 40 to 70% depletion of the initial oxygen content are considered the most reliable.

Calculation: The p.p.m. B.O.D. of each dilution is found by subtracting the p.p.m. dissolved oxygen in the dilution from that of the blank, multiplying by 100 and dividing by the percentage dilution. The results from each dilution are averaged to give the final result.

Calculation: DO stands for dissolved oxygen in p.p.m.; S indicates the raw undiluted sample; bi stands for blank after incubation; di for diluted sample after incubation; cd for calculated diluted sample before incubation; P = % sewage (in decimals) in sample as incubated (% dilution water in this sample therefore = 1-P); then:

$$DO_{cd} = DO_{bi} \times (1-P) + DO_s \times P$$

$$\text{ppm. B.O.D} = (DO_{cd} - DO_{di}) \frac{1}{P}$$

As a matter of fact, the DO for the blank should have been taken before incubation, but as only a small error is made the figure for the incubated blank is used. DO_s the dissolved oxygen in the raw sewage is very small for sewage and sewage sludge, unless aerated. Therefore, it is usually not necessary to make the test on the raw undiluted sewage, also the term $DO_s \times P$ is only a small fraction of that amount and can be omitted.

If the sample be chlorinated, it should be dechlorinated with 0.025 normal sodium thiosulfate ($Na\ HSO_3$). In that case, as in the case of sterile industrial wastes of sewage, seeding with sewage bacteria is necessary. This is accomplished by adding settled (not filtered) sewage or polluted river water in amounts to give about 0.5 ppm. oxygen depletion in the seeded blank. Samples collected during the winter months or where algae are actively growing may be supersaturated with air. When the D.O. exceeds 9 p.p.m. the excess air should be expelled by heating of the sample to 20° C. and vigorous shaking.

There are several other important tests relating to sewage control about which the sanitarian should be acquainted. That for suspended solids is required in the operation of an activated sludge plant. It would be well therefore to describe the various tests for solids.

Total Solids. Evaporate 100 ml. of sample in an ignited and tared dish, dry to constant weight at 103°C., cool in desiccator and weigh. (This usually requires 1 hour drying at 103° C.) The mg. per liter is reported as parts per million total solids. Calculation: ppm. total solids = mg. of residue x 1000 ÷ ml. of sample.

Total volatile and fixed solids are determined by igniting the above total solids at 600° C. in an electric muffle (usually requiring 10 to 15 minutes.)

The mg. loss on ignition per liter is reported as parts per million volatile solids, and the mg. residue per liter as parts per million fixed solids. Calculation: same as total solids.

These results on total solids, volatile solids and fixed solids are subject to considerable error because of losses of volatile compounds during evaporation, or carbon dioxide and volatile minerals during ignition, and to the presence of calcium oxide in the ash. In the interpretation of results these possible errors must be recognized.

Total Suspended Solids. Filter 50 to 100 ml. of sample through the weighed Gooch crucible using suction. Wash with distilled water. Dry at 103° C. for 1 hour, cool in a desiccator and weigh. Report the mg. solids per liter as parts per million suspended solids.

A rapid test for suspended solids of mixed liquor or return sludges in activated sludge plant is by the use of an aluminum dish, 92 mm. inside diameter and 25 mm. high with bottom perforated similar to a Buchner funnel, and a closely fitting filter paper.

Dry aluminum dish and filter paper in oven. Cool in dessicator and weigh. Wet the filter paper, place the dish with paper on rubber ring in Buchner funnel and apply about 20 inches of vacuum to the flask. Immediately add 50 to 100 grams of sludge to the dish and after the water has been extracted, dry in oven for about 30 minutes at 103°C. to 105°C. Cool in desiccator and weigh. Report the mg. solids per liter as p.p.m. suspended solids. If necessary the original sample may be diluted and an aliquot portion taken.

Volatile and Fixed Suspended Solids. As stated above, the volatilization of organic matter, carbonates, and ammonium salts from sewage solids is subject to a great many errors. It should be done in an electric muffle furnace at 600°C. Ignite the suspended solids (10-15 minutes.) Cool in a desiccator and re-weigh. Report the mg. lost on ignition per liter as parts per million of volatile suspended solids, and the mg. ash per liter remaining as parts per million fixed suspended solids.

Dissolved Solids. Dissolved solids may be obtained by difference between total solids and suspended solids, or by evaporating a filtered sample according to above procedure for total solids.

There are several methods for doing the Dissolved Oxygen test, depending on the type of sample to be analyzed. The Winkler Method is used for relatively pure waters. There are five modifications of the Winkler method: The Alsterberg or sodium azide procedure, used where appreciable amounts of nitrites are present (over 0.05 p.p.m.); the Rideal-Stewart procedure, used in the presence of ferrous salts and nitrites; the alkaline-hypochlorite modification, used in the presence of sulfites, thiosulfates, polythionates, free chlorine, or hypochlorites; the alum flocculation modification, used in the presence of suspended solids which interfere with the determination of dissolved oxygen; the sample-blank modification, used to compensate for errors due to various interferring chemical substances. Only the Winkler and the sample-blank methods will be described. The other may be found in "Standard Methods for the Examination of Water and Sewage."

The Winkler Method: Used for relatively pure waters. To the filled bottle, 1 ml. each of manganous sulfate ($MnSO_4$) solution and alkaline-iodide solutions are added below the surface of the sample. Shake well several times by inverting for about one minute until no precipitate remains in the upper half of the bottle after settling of the manganous hydroxide which through absorption of oxygen has become yellowish brown. The time of shaking can be cut in half (20-30 seconds) by using 2 ml. of $MnSO_4$. Add 1 ml. of concentrated sulfuric acid by allowing it to run down neck of bottle; this liberates iodine which is proportional to the presence of dissolved oxygen. Withdraw 200 ml. of sample and titrate with 0.025 normal sodium thiosulfate. Actually 201.6 ml. are withdrawn because of the 2 ml. of reagent added to sample.

Calculation: p.p.m. of dissolved oxygen = (ml. of 0.025 normal sodium thiosulfate x 200) ÷ ml. of sample titrated.

Sample-blank Modification of the Winkler Method. The objective of this method is to compensate for errors due to various interfering chemical substances by analyzing simultaneously two bottles of the sample and varying the sequence of reagents so that all of the deductible errors will appear in one bottle. The procedure will give excellent results in sewage effluents unless large amounts of organic oxygen consuming substances be present.

Fill 2 matched 250 cc. bottles with aliquot parts of the same sample. Stopper immediately. Mark one as the true sample "A", and the other one as the blank "B". To the true sample "A" add exactly 2 ml. of iodized alkaline iodide solutions (produced by adding 10 drops of iodine solution to 500 ml. of the alkaline iodide Winkler reagent) followed by 2 ml. of manganous sulfate reagent. Restopper and agitate by alternately reversing the bottle for exactly 40 seconds. Put bottle A aside to allow precipitate to settle. While this settling takes place in A, add to B in the order indicated, 2 ml. iodized alkaline iodine solution, 2 ml. of sulfuric acid, and 2 ml. of manganous sulfate reagent. After the addition of each reagent, restopper the bottle and up-end it for proper mixing, waiting 10 to 15 seconds before adding the next reagent, then put bottle B aside.

After precipitate has settled in bottle A, add 2 ml. of sulfuric acid and mix. As soon as the precipitate has dissolved, the sample should be titrated. Titrate a 100 or 200 ml. sample from both bottles with correction of fluid lost by adding reagents, as discussed under the Winkler Method.

Calculation: Subtract the ml. of sodium thiosulfate required for B from that required for A, and use the difference for the calculation similar as that for the Winkler Method:

$$\text{Corrected volume of sample to be taken for titration, not in the computations} = \frac{\text{ml. of sample} \times \text{capacity of bottle}}{\text{capacity of bottle} - (\text{ml. of manganous sulfate} + \text{ml. of pot. iodide})}$$

Since the differentiation between nitrates and nitrites indicates to the sanitarian not only the stage of the nitrification process in the sewage, but could also give him information as to recent or past pollution of water, these tests will be described.

Nitrate and Nitrite Nitrogen. For normal sewage add 2 ml. of nitrate-free sodium hydroxide to 100 ml. of sample and concentrate by boiling in a casserole to about 20 ml. to remove free ammonia. Rinse this concentrated sample into a 50 ml. Nessler tube (or graduated test tube), make up to the mark with ammonia-free water, add one strip of aluminum foil, and cover the tube with a loosely fitting stopper (or Bunsen valve) to protect the solution from dust. Allow to stand at 20°C. or above for 6 hours or over night. Nesslerize 1 to 5 ml. of the clear liquid after dilution to 50 ml. with ammonia-free water, and compare with ammonium chloride standards. Calculation: p.p.m. of nitrate and nitrite nitrogen = (ml. of ammonium chloride standard x 5) ÷ ml. of Nesslerized solution; or, p.p.m. of nitrate and nitrite nitrogen = (mg. of nitrogen in the ammonium chloride standard x 500) ÷ ml. of Nesslerized solution.

Nitrite Nitrogen. Take a fresh sample and place in a standard Nessler tube 0.1 to 10 ml. of the sample, clarified if necessary with zinc sulfate and sodium hydroxide as described for ammonia nitrogen test, and dilute to 50 ml. At the same time prepare in Nessler tubes a set of standards by diluting to 50 ml. with nitrite-free water various amounts (as specified in the ammonia nitrogen test) of standard nitrite. Add 1 ml. of sulfanilic acid solution and 1 ml. of a-naphthylamine acetate solution to the sample and to each standard. Mix thoroughly and allow to stand 10 minutes but no more than 30 minutes. Compare the sample with the standards. Calculation: p.p.m. nitrite nitrogen = ml. of standard x 0.5 ÷ ml. of sample.
Nitrate Nitrogen = Nitrate and nitrite nitrogen - nitrite nitrogen.

Plant Operation

The two fundamentals in the successful functioning of any sewage plant are:

1) Adequate and correct design of the plant as a whole to meet the various conditions in the particular situation.

2) Intelligent application of skill and knowledge by the operator of both physical appearance and laboratory control.

The first factor is the task of the engineer. The second task is that of the operator. The sanitarian should be acquainted with the basic principles of plant operation. The operation of a sewage plant demands that:

1) The effluent produced be of a quality sufficient to meet the requirement of the receiving stream.

2) Odors and nuisances be avoided.

3) The management be efficient in maintaining minimum operating and labor costs.

These demands may be satisfied if the operator be acquainted with the:

1) Incoming raw sewage quantities and characteristics.

2) Existing plant facilities.

3) Receiving stream.

The Raw Sewage. Concerning this, the following should be known:

1) Daily quantity entering plant.

2) The maximum and minimum rates of flow daily, weekly, and seasonally.

3) The character of the sewage, sludge, and effluent as determined by various tests mentioned in the foregoing discussion.

Plant Characteristics and Efficiency. Studies should be made of these factors. Such studies include detention periods of settling units for the various sewage flow rates, digestion capacities based upon quantities of sewage received, rates of application of sewage and air to oxidizing units, adequacy of sludge drying and dewatering units, and time of contact for sterilization. The overall plant efficiency is measured by the reduction of B.O.D., bacteria, and suspended solids. The efficiency of individual plant units is measured by a variation of tests which may be classified as tests measuring efficiency directly and tests aiding as a guide to operation. The following table outlines this classification.

Table 14. Function of Various Tests

Sedimentation Units		Oxidation Units		Digestion Units		Sterilization Units	
Direct Efficiency	Operation Guide	Direct Efficiency	Operation Guide	Direct Efficiency	Operation Guide	Direct Efficiency	Operation Guide
Settleable Solids	Suspended Solids pH B. O. D. Ammonia and Nitrogenous Compounds	B. O. D. Suspended Solids	Ammonia Nitrites Nitrates Dissolved Oxygen pH	% Ash % Moisture	Suspended Solids in Super-natant Liquor Tempera-ture pH Gas	Bacteria	Residual Chlorine

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Characteristics of Receiving Stream. Operation information should include:

1) Quantity of flow during different seasons of the year.

2) Time of flow between the consecutive points in the stream below the plant outfall.

3) Time of flow to critical points of stream water usage such as swimming and recreational areas, or public water supply intakes.

4) Character of stream bed with respect to location of zones of pollution.

5) Location of other points of pollution above and below the plant outfall.

The important tests performed on the receiving stream are, bacteriological, B. O. D. and dissolved oxygen.

Common Operating Problems.

Screens and Grit Chambers. Odors from this source are commonly due to floating sludge. Floating sludge is caused by:

1) Lack of frequent enough withdrawal of settled raw sludge from sludge compartments, allowing decomposition and gas formation with consequent rise of some sludge to the surface.

2) The two rapid withdrawal of sludge from sumps, thus leaving some sludge, which does not move rapidly enough, on the slope. This allows decomposition, gas formation, and rising of sludge to the surface. If possible, slow continuous withdrawal is best.

3) Grease, soap, and industrial wastes which should be eliminated before they reach the sewers, or by removal from the surface of settling tanks.

4) Excessive retention periods which allow odor production from both the surface of the tank and from discharged sewage. If the retention period cannot be reduced, pre-chlorination can be interposed.

5) Floating scum in open influent and effluent channels of settling units. This may be skimmed off, or alteration of the slope or velocity distribution in the channels may be made, resulting in a reduction of the period of retention in those channels.

Other sources of odor are when:

1) Septic or stale sewage due to long distant travel enters plant. The establishment of points of chlorination along the route or prechlorination of septic sewage before it enters the treatment plant may be a help.

2) Sediment accumulates in the upper chamber of the Imhoff Tank. The sides and slopes of the sedimentation compartments of Imhoff Tanks should be carefully scraped and all solids pushed down through the slots at least once weekly. The slots should be kept free from obstruction with chain drop. Never should the sludge in the lower compartment be allowed to rise into or above the slot.

Mosquito breeding nuisance may occur in places where liquid is stagnant.

Problems in efficient removal of settleable solids may arise from poor designing of the plant over which the operator has no control except to resort to chemical treatment. Such uncontrollable factors are insufficient length of detention for sewage flow, and excessive velocities of flow thru tank. One of the most common causes of poor removal of settleable solids is short circuiting of flow through the tank due to improper distribution of flow and poor baffling at the inlet and outlet ends. The short circuits can be traced by dyes and salts. This can be remedied by placing baffles, preferably of the over and under type in the tank at locations which will correct the flow. Another common cause of settling inefficiency is stale and decomposing settled sludge. This can be remedied by keeping the tanks clean. Tank efficiency may also be reduced by allowing too great an accumulation of settled solids on the bottom of unit. Development of algae in sewage filters should be guarded against as they obstruct aeration and will finally cause pooling of the filters.

Digestion Units. Problems in operation of digestion units generally revolve around the production of:

1) An odorless sludge in minimum time.
2) A suitable quality of supernatant liquor with respect to odor and solids content.
3) A sludge of low water content.
4) A sludge of quick dewatering and drying characteristics.

Odors from digestion tanks are closely linked with poor digestion. When the tank capacity is sufficient and no inhibitory substances such as toxic industrial wastes are present, good sludge and supernatant liquor can be produced if:

1) Proper temperature of digestion be maintained, the optimum being about $90^{\circ}F$.
2) Proper ratio of raw sludge additions to digested sludge be maintained.
3) Uniform application and mixture of the applied raw sludge to seeding material be maintained.

Foaming may be caused by temperature rise in the spring in the digestion with a corresponding increase in digestion activity of the winter accumulation. This can be prevented by preparing adequate tank capacity during the summer period when the rate of digestion is high so that a minimum amount of ripe sludge will be drawn during the winter, and by the addition of lime to the digestion tank mixture in the fall when the temperatures drop and the tanks show indication of becoming acid. The addition of lime to the raw sewage solids coming to the tank should be continued through the winter, or when this is not feasible milk of lime may be added directly to the tank. The pH measurement is the best indication as to how much fresh solids can be added to the digestion tank. The pH should not fall below 6.8 or 6.9. Uniform application and mixture of the fresh sewage solids with the ripe sludge cannot be too strongly stressed. Where no facilities have been provided for changing the points of application of fresh sewage solids, recirculation of the tank contents at occasional intervals is helpful, circulating the liquid from the neutral zone over the scum blanket.

One of the most important precautions in the operation of sludge digestion is to guard against the withdrawal of excessive quantities of ripe sludge, remembering that the solids content of digested sludge is frequently much higher than the added sludge. To prevent the depletion of sludge, supernatant liquor should be withdrawn whenever and as long as possible.

The rate of withdrawal of sludge must not exceed the rate of movement of bottom sludge to the drainage outlet lest fresh or partially digested material be taken from the tank. Therefore sludge should always be withdrawn from the digester at the slowest possible rate. A continued thick consistency of sludge indicates a proper rate of withdrawal. Toxic industrial wastes which retard or destroy sludge digestion should be neutralized chemically or, preferably, neutralized at the source.

Supernatant liquor should be free of obnoxious odors and low in suspended solids. This may be accomplished by:

1) Slow withdrawal of the liquor to prevent scouring the top level of the sludge or the bottom

level of the scum.

2) Preventing short circuiting of fresh material from inlet to outlet.

3) Preventing too rapid digestion and consequent disturbance of the liquid zone by violent gas evolution.

When excessive suspended solids are found chronically in the supernatant liquor, treatment of the liquor with lime or coagulants is required.

A good digested sludge has a low moisture content or a high solids content. This depends upon the concentration and character of the raw solids added, the temperature and length of digestion, and the storage time. When fresh solids are digested, the final ripe sludge concentration usually varies between 8 and 12% whereas as the activated sludge process produces a concentration usually between 2.5 and 6% solids and even higher, usually about 5%. Very thin sludge usually indicates insufficient digestion and storage capacity, faulty operation, or the presence of poisonous wastes. Activated sludge has a high moisture content, and although digestion helps to concentrate the sludge the solids content may still be low when removed from the tank. Chemically precipitated sludges may have the same characteristics. Judicious concentration of solids in settling units before discharge to digesters is frequently of material help.

Rapid dewatering characteristic of ripe sludge is important to efficient operation since a poorly dewatering sludge materially reduces the outlet capacity of the dewatering and causes the digesters to be inadequate to hold sewage solids for proper digestion. The dewatering capacity of sludge increases as the degree of sludge digestion increases. Chemicals may be used to aid dewatering.

Supernatant liquor can be disposed of on sand beds or returned to settling units. This liquor has a high B.O.D. and when digesters operate poorly a heavy load is placed on the oxidation devices. Chemical treatment of the supernatant liquor with lime, alum, hypochlorite of lime, ferric chloride, or other precipitating agents, before its return to settling units, may be essential to avoid difficulties.

Oxidation Units. Objectionable odors from these units come from the sewage applied or from a lack of aerobic conditions in the oxidation unit itself which causes putrefaction.

Most problems related to the trickling filter resolve themselves largely in the control of the quantity and quality of biological film on the filter stones. The factors affecting film accumulation are:

1) Quantity of food material.
2) Rate of application.
3) Temperature.

In standard trickling filters the biological film usually sloughs off in the spring and fall and may cause much trouble if the film accumulation is great. In high-rate filters the coagulated material on the filter film together with part of the film is continuously "unloaded" and washed from the bed as sludge. There are several methods of controlling the quantity of film. They are:

1) Total submergence of filter stone under the applied sewage for 12 to 48 hours will cause film to disintegrate and be carried off in effluent.

2) Chlorination of the applied sewage to a residual up to 5 ppm. in the filter influents for periods of 2-4 hours at intervals of 2-3 days during the night, or periodic spreading of hypochlorite of lime over filter surface will prevent excessive growth.

3) Rest the filter bed. This is usually impractical.

4) Forking over the top few inches of stone, if the accumulation of film be mostly on top.

5) Flushing of the surface with a fire hose while loosening the rock with a bar. These methods should only be used when absolutely necessary since they interfere with purification efficiency of the filter.

If the quantity of suspended solids in the applied sewage be much greater than the biological assimilation capacity of the filter, the solids will accumulate and cause difficulties. This is corrected by controlling the applied sewage. Grease may cause filter stoppage. Control of grease at the source should be instituted, but if the condition be temporary, chlorination or forking will relieve the situation. Filter efficiency is influenced by materials toxic to biological life, such as laundry wastes, acids and alkalies. Control at the source is preferable, or neutralization at the plant.

The Psychoda fly may breed in the filter. This is controlled by:

1) Reduction in food supply and film development.
2) Insecticides and repellents.
3) Filter flooding by complete submergence of filter stone for 24 hours.

Activated sludge plant operating troubles in a properly designed plant are largely concerned with:

1) Introduction of enough air to maintain aerobic conditions throughout the aerator and final settling tanks without over-aeration:

The quantity of air necessary will depend upon the efficiency of mixing, the oxygen demand of sewage, the quantity of the activated sludge, and the quality of returned sludge. The sewage should reach the aerators in the freshest conditions possible. Where air is injected through nozzles or porous plate bottoms, the quantity of air can be regulated by valves; where aeration is being accomplished by the cascade method, the circulation pumps can be automatically stopped during a period up to 15 minutes per hour continuously by electric clock contacts.

2) Proper use of facilities to create good mixing and calculation of the mixed liquor in the aerator:

This depends mainly on the design, but can be regulated to some extent by variable speed controls of mixing and aeration facilities, or by placing baffles at critical spots in the aerators. The tendency for longitudinal short circuiting of the sewage through the tank can be decreased by the strategic placing of baffles. Dead areas where circulation is poor should be watched for. Local points showing low dissolved oxygen indicate insufficient aeration or mixing, while high dissolved oxygen tests indicate insufficient velocity in mixing to keep suspended solids in uniform distribution. Such conditions produce septic activated sludge floc and sewage liquor.

3) Production of a quick settling and dense sludge floc efficiently retained in final tanks and requiring the least volume for the capacity in sludge digestion or sludge dewatering units. The factors which help maintain a good density of the sludge floc are:

a) Greater aeration or oxidation of the floc, or reduction of aeration when the sludge is over-aerated.
b) Balancing the proportion of return sludge.
c) Concentration and reaeration of the return sludge.
d) Partial chlorination of the sludge or aerator tank contents.
e) The use of lime, chloride of lime, ferric chloride, or other chemicals.

A very light or more buoyant so-called "bulky" sludge can disrupt the plant operation throughout. "Bulking" is primarily caused by sudden disturbance in biological equilibrium which permits a heavy growth of zoogleal bacteria of which Sphaerotilus natans is most prominent. These bacteria form a jelly like mass due to the swelling of the cell membrane by absorption of water. When this begins to happen the amount of sludge carried in the aerator should be reduced in order to reduce the oxygen demand, the air supply should be increased and the sludge kept fresh. Such measures as diluting the sewage with effluents or water, or using chlorination should be practiced with caution. Bulking causes an increased volume of the sludge, and reduces the supernatant liquor zone causing sludge to be swept with effluent. This causes overloading, the need for withdrawal of poorly digested sludge which dries and dewaters poorly, and a consequent relative reduction of the capacity of the units carrying the sludge. Therefore, the operator should always follow this cardinal rule: "Maintain, at all times, a minimum quantity of aerator solids consistent with adequate purification, a minimum quantity of sludge in the digesters consistent with good digestion, and sludge drying facilities readily available for the fullest capacity of units carrying activated sludge."

Dewatering Units: Most of the labor in sand filter operation is applied to cleaning, raking and removing the organic material that accumulates on the sand surface. The condition of the sand surface is directly related to purification efficiency, odors, and other operation problems. An excess of organic matters on the top of the sand will cause pooling, and create anaerobic conditions below the surface resulting in production of odor. Correction of this requires:

1) Drying of sand bed unit.

2) Scraping off top layer, being careful not to rake the organic material into lower sand levels and causing complete clogging.

3) Removing about 1/2 inch of top layer if raking does not help. The top layer of sand should always be removed when replacing sand normally lost in filter cleaning.

Clogging may also be caused by grease wastes, and excessive growth of certain forms of algae or fungi in the sand. Good weather should be taken advantage of in preparing beds for bad weather conditions. Excessive application of sewage while using too few bed sections may cause operating trouble. Too short intervals of bed resting may cause clogging. Judicious application rates and rest intervals for beds are very important. The control of clogging from algae and fungi may be accomplished by partial sterilization of sewage applied to beds by means of chlorine, copper sulfate, or other germicides. Intermittent clogging usually needs only one or two doses of sterilizing agent, while persistent clogging will need continuous application. This must be done with care in order not to interfere with the purification process in the bed.

Dewatering of sludge or sludge drying beds will be efficient if the sludge has been well digested, the bed is not clogged, and the weather is good. Poorly digested sludge tends to form a heavy tenacious mat over both the sand and sludge surface, thus retarding drainage and evaporation. Undecomposed grease wastes retard or stop filtration. Over-filling of beds with excessive depth of sludge may cause clogging. The remedy for clogging is to remove 1/4 to 1 inch of sand and replace with clean material. Where sludge dewaters poorly, alum should be added between sludge outlet and sand bed. Other chemicals may be used, such as ferric chloride with or without lime, chlorinated copperas, and ferric sulfate. Of these, ferric chloride is the more efficient.

Utilization of Sewage Sludge as Fertilizer

Although sludge gas, produced by the digestion of sewage sludge, is the most generally recoverable value in sewage sludge, occasionally, depending on local agricultural and also marketing conditions, there may exist or be created a market for the dried sludge of sewage disposal plants for the use as fertilizer. Heat drying of activated sludge in large amounts for sale as fertilizer may be profitable in relatively large treatment works; in smaller treatment works and those of other types such sale may be considered as a convenient and economical means of sludge disposal.

The fertilizing value of sewage sludge depends on its content of nitrogen, phosphoric acid, and potash. Sludge may serve as a source of humus in the soil. Humus is of value as a soil conditioner; it improves the water-holding and erosion-resisting capacity of the soil and furnishes a substrate for useful soil bacteria. As the mineral contents of sewage sludge vary with the type of treatment process from which it results, and different soils have different deficiencies for the crops to be grown on them, it is evident that the sludge must be suitably prepared with correction of such deficiencies, and suitably applied.

A good source of information on sewage sludge as fertilizer is the Manual of Practice No. 2., Federation of Sewage Works, Champaign, Ill., 1946. "Utilization of Sewage Sludge as Fertilizer", from which the following data are collected.

Fertilizer is graded in figures according to the content of the major elements required for soil conditioning. For instance, a fertilizer 10-6-4 has 10% nitrogen in weight, 6% of phosphoric acid ($P_2 O_5$) and 4% of water soluble potash ($K_2 O$). These figures vary greatly in sludges of varied treatment methods and also in products of different plants using the same treatment method. Little can be said, therefore, of specific value of sludge produced by a certain method, but it is shown by tests that sewage sludges compare favorably, especially in nitrogen content, with other organic materials, and that activated sludge contains the highest percentage of ferilizing elements.

Sludge is settled sewage and may be fresh, or digested, or activated fresh, or digested, or chemically precipitated. It may come from open drying beds or from glass-enclosed green house type shelters. Fresh sludge, except heat-dryed activated sludge, is not a desirable fertilizer because of its grease content, odors, and weed seeds, and because it may include pathogenic organisms. It should be used only in forage crops and plowed in promptly.

There is an old belief among farmers that odors from sludges are a measurement of fertilizing value —the stronger the odor, the higher its value. This is not the case.

Liquid sludge, digested or undigested, is difficult to handle and requires a much greater quantity for the same results. For this reason unless in special cases where it can be piped to the farm, or when tank trucks are used, dried sludge is used as fertilizer. When air-dried it may be hauled economically over distances up to 20 miles; if high in nitrogen (the nitrogen varies from 0.5% - 3%) it may be heat-dried and transported over greater distances. The sludge should be plowed under soon after distribution. Heat-dried activated sludge contains 3 - 6% of nitrogen and up to 2 1/2% of phosphoric acid.

Heat dried material is generally ground or pulverized and screened; it should be kept below 10% moisture content and be protected from the weather to prevent caking, disintegration of the bag, or even spontaneous combustion. Air-dried sludge is usually disintegrated by means of a manure spreader type disintegrator. Repeated forking aids the drying process. In Southern California such material is trucked into the orchards, where it is spread and mixed into the soil.

It averages 1.5 - 2.5% nitrogen, 1 - 1.5% phosphorus, 0.5 - 1% potash, and 40 - 50% organic matter.

Undigested activated sludge, as stated, has a much higher nitrogen content, of which about half is readily absorbed by the vegetation. It is good for cotton, corn, barley, cabbage, lettuce, potatoes, radishes, tomatoes, tobacco and for lawns.

Lime precipitation sludge has a special value in acid soil.

Sludge as Fertilizer and Disease Bearer.

There are several diseases in this country to be considered in connection with fecal matter: typhoid fever, poliomyelitis, amoebic and bacillary dysentery, tuberculosis, Weil's disease, usually caused by rat excreta, and gastro-enteric disturbances. Likewise sewage may contain eggs of intestinal parasites.

The typhoid bacillus, Salmonella typhi, usually does not survive in sewage sludge longer than seven days under normal conditions. Wolman recommends at least ten days digestion for all sludge and application to the ground before planting so as to avoid any contact with growing vegetables. Drying of sludge will greatly reduce the Sal. typhi content. Wet activated sludge definitely cannot be considered harmless.

The poliomyelitis virus has been demonstrated in human feces and sewage, and remains active in water and milk for periods up to a month. Thus far is has not been reported in sewage sludge; experiments with activated sludge showed that a sludge of 1000 p.p.m. solids content inactivated the virus after 6 hours' aeration.

Tuberculosis bacteria, Mycobacterium tuberculosis, have been removed from streams several miles below a sewer outlet, and have survived more than 93 days in sewage and sewage polluted streams.

Weil's disease has been contracted by sewage workers in large cities. Amoebic dysentery, caused by Endamoeba histolytica, which has the ability to form protective cysts under adverse conditions, may survive as long as 90 days at 10°C. in sewage. The cysts do not withstand sludge digestion, but hookworm ova and eggs of other intestinal animal parasites may survive digestion and air drying. The amoebic cysts and other parasites have been found in settling tank effluents and to pass through trickling filters. It is believed that none of these parasites is found in heat dryed sludges where the temperature reaches 700 - 800°F. for at least five minutes. Hence, the committee on sewage disposal of the A.P.H.A. concludes that heat-dryed activated or digested sludge may be used as fertilizer, and that air-dryed digested sludge is satisfactory for the preparation of soil except where vegetables which are eaten raw are to be grown.

Regulations for Sewage Disposal

From the information in this chapter and that in the chapter on Rural Excreta Disposal, rules and regulations for sanitary code purposes can be developed. The regulations should give the definitions of various terms such as sewerage system, sewage, storm water, industrial waste, industrial liquid waste, public sewer, house connection sewer, industrial connection sewer, industrial waste treatment plant, sewage treatment plant, semi-public sewerage system, industrial

sewerage system, private sewerage system, cesspool, dry well, home or domestic sewage, house sewage plumbing. The regulations should include the procedure of the approval of plans for building, altering or adding to the various types of sewerage systems; the protection, supervision and maintenance which would include operation permit, investigations of the sewerage system to determine compliance, prevention of hazards or nuisances by sewage discharge, the furnishing of reports by operators to determine compliance. The regulations should include a listing of the standards that will satisfy compliance relating to conditions which are prohibited, such as those conducive to fly and mosquito breeding, noxious and offensive odors, the deposition of excreta particles along the margins of streams, endangering drinking water supplies, stream pollution, the discharge of certain proscribed materials into the sewers such as greases, oils, coal tars, paints and paint waste products, petroleum products, unshredded garbage, industrial wastes of certain character, undigestible materials, any materials that would clog the system or cause explosion or have other detrimental effects, materials that would interfere with the biochemical functioning of the stream waters, the prescribed conditions and procedures for connecting to a public sewer and for the irrigation of the ground with sewage. The regulations should provide for the conditions under which pretreatment is mandatory before industrial wastes are discharged in the sewerage system. The regulations should prescribe standards for design, construction and performance of sewerage systems which would include sizes, depth and location of sewer mains, principle laterals and house connections, the velocity of flow, manhole design and distances apart. The regulations should prescribe in detail the data that must be submitted with an application for construction, alteration or extension of a system. The regulations should include the requirements for individual or home sewage disposal systems including the character of soil, the return of unpolluted waters (such as from air conditioners) to the ground, the reclamation of sewage effluent for industrial purposes, the removal and transportation or disposal of sewage, sludge or human excrement including the requirements for permits and registration of vehicles of common carriers (Department of Health, Education and Welfare regulations published in the Federal Register, May 16, 1947) and the standards for tank wagons, tank trucks, tank cars, cans or any other containers, their watertightness, construction, piping, valves, connections, inlet and outlet connections, pumps, check valves, cylinders, diaphragms, spillage and leakage, connections with unpolluted water supplies, and the method and place of disposal.

Boat and Marina Pollution

Pleasure boating is the most important form of recreation in America today in terms of dollar volume. Americans spend more money on boating than on baseball, fishing, golf or any other single recreational activity. In 1950 there were 3.5 million registered pleasurecraft, but ten years later there were 7 million, and in 1964 there were 8.5 million. This means that there is one boat in this country for every 25 people.

The tremendous increase in boating has resulted in the growth of a related industry that is almost as startling. Over 5,200 marinas now serve the American boating public on our lakes, along the shores of our rivers and coastlines.

Approximately 90% of the "covered" boats being manufactured today, have galley and/or toilet facilities, and the wastes collected by these facilities are being discharged mostly into the waters on which the craft is operating.

To the wastes discharged from toilet and galley facilities, and from marinas, are added the cans, bottles, boxes, and paper tossed overboard by thoughtless boaters. As a consequence, many of our recreational waters are becoming polluted to an alarming degree; so much so that other legitimate demands upon the water resource are being curtailed and in some instances, denied altogether.

Today, there are many states that have either no laws to regulate disposal of wastes from boats or marinas, or have laws which are inadequate or unenforceable. The Outboard Boating Club of America recommends the following model Code which is based on the New Hampshire State Act of 1957 and which is also endorsed by the New England Water Pollution Control Commission:

An Act Relative to Marine Toilets and Disposal of Sewage from Boats.

The technical requirements of what must be included in the title vary from state to state. These requirements must be adhered to exactly or the statute will be held to be invalid by the courts.

Definitions: The term "watercraft" means any contrivance used or designed for navigation on water.

The term "sewage" means all human body wastes.

The term "marine toilet" means any toilet on or within any watercraft.

The term "waters of this state" means all of the waterways on which watercraft shall be used or operated.

(In some states, it may be desired to limit the application of this act to certain waters only and thereby exempt large bodies of water where there is no conceivable boat pollution problem. The affected areas could be listed or the Department be authorized to make a finding that a particular waterway should or should not be covered by the act.)[1]

The term "Department" means the (here insert the state agency which shall administer this act and issue certificates of number for boats).

(The choice of agency is of course a matter for each state to decide for itself. It is recommended, however, that consideration be given to the state agency dealing with water pollution problems in general.)

Marine Toilets - Restrictions: No marine toilet on any watercraft operated upon waters of this state shall be so constructed and operated as to discharge any inadequately treated sewage into said waters directly or indirectly. No watercraft shall be so equipped as to permit discharge from or through its marine toilet, or in any other manner, of any inadequately treated sewage at any time into the waters of this state, nor shall any container of such inadequately treated sewage be placed, left, discharged or caused to be placed, left or discharged in or near any waters of this state by any person at any time, whether or not the owner, operator, guest or occupant of a watercraft.

Marine Toilets - Manner of Operation: Any marine toilet located on or within any watercraft operated on waters of this state shall have securely affixed to the interior discharge opening of such toilet a suitable treatment device in operating condition, constructed and fastened in accordance with regulations of the Department, or some other treatment facility or method authorized by regulation of the Department. All sewage passing into or through such marine toilets shall pass solely through such devices. The Department shall have authority to carry out the provisions of this act by appropriate regulations.

(As previously noted, these treatment devices are now available at very moderate cost. With further improvements likely in the near future, it is unwise to "freeze" any particular specifications for such a device in the statute. All technological changes can be readily incorporated into rules and regulations. Note that the basic idea behind these devices is not patentable.)

Local Regulations Prohibited: Through the passage of this act, the state fully reserves to itself the exclusive right to control the discharge of sewage from marine toilets.

(With this law on the statute books of the state, there is no need for any additional or differing local rules. The latter could only serve to confuse and harass the boating public.)

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1. The text enclosed in parenthesis is not part of the code, but is explanatory only.

Enforcement: All watercraft located upon waters of this state shall be subject to inspection by the Department or any lawfully designated agent or inspector thereof at any time for the purpose of determining whether such watercraft is equipped in compliance therewith.

Certificate of Number: The Department may require persons making application for a certificate of number for a watercraft pursuant to (here give statutory citation to state Boat Number Act) to disclose whether such watercraft has within or on it a marine toilet, and if so, whether such marine toilet is adequately equipped with a treatment device securely affixed thereto as required by this act. The Department is further empowered to refuse to issue a certificate of number or a renewal thereof if such treatment device has not been affixed as required by this act.

Penalty: Any person who violates any of the provisions of this act or regulations of the Department promulgated hereunder shall be deemed guilty of a misdemeanor and upon conviction shall be punished with a fine of not more than $100, or by imprisonment of not more than 30 days, or by both such fine and imprisonment at the discretion to the court.

Savings Clause: If any court shall find any section or sections of this act to be unconstitutional or otherwise invalid, such findings shall not affect the validity of any sections of this act which can be given effect.

Effective Date: The effective date of this act shall be _____. (It is suggested that the effective date of this act be delayed so that all persons affected by its provisions will have a reasonable amount of time to become acquainted with it and secure the required treatment device.)

The following are recommended practices or standards (by the American Board and Yacht Council Inc.) for devices designed to treat human waste discharges through marine toilets:

Effluent Requirements: A sewage treatment for marine toilets should discharge an effluent meeting the following minimum standards:

a. Free of unsightly solids.

b. Containing a most probably number (MPN) of coliform bacteria not exceeding 240 per hundred milliliters.

Pretreatment of Solids: Prior to disinfection, solids shall be sufficiently divided into fine particles to permit the required degree of disinfection necessary to meet the above minimum effluent standards.

Disinfecting Agent: The disinfecting agent shall meet the following conditions:

a. Be easily obtainable.

b. Constitute minimum hazard when handled or stored and form no dangerous gases.

c. Be sufficiently effective in relation to the detention time of the device to meet the above effluent requirements.

Materials: a. Materials used shall be such as to withstand the corrosion effects of the sewage, the disinfecting agent, and the flush water.

b. Materials used should have chemical and/or galvanic compatibility.

Design and Construction: The device shall:

a. Be of ample strength for safe operation.

b. Incorporate a detention chamber of size sufficient to produce an effluent which complies with the above requirements.

c. Be of the type which does not depend on septic action as part of its treatment.

d. Prevent the escape of dangerous gases or obnoxious odors to boat interiors.

e. Provide for ease of cleaning, ease of maintenance, and ease of replenishment of the disinfecting agent.

f. Function automatically with the operation of the marine toilets.

g. Not require too frequent replenishment of the disinfectant.

h. (1) Have design and construction of such intent that the danger of ignition of flammable vapors within or external to the unit will be prevented. (2) Use electrical components and connections complying with applicable standards of the American Boat and Yacht Council.

i. Be so designed that, when properly installed, malfunctioning of its components will not endanger the boat in which it is installed by permitting water to enter the hull interior.

Installation: a. Installation of the device and its piping should allow ease of servicing and replenishment of the disinfecting agent.

b. The device shall be adequately secured independently of any connecting piping.

c. All piping shall be sufficiently strong and durable to withstand any pressure that might be imposed upon it by normal operation of the device. The interior of piping or hose shall be such as not to retain solid matter.

d. Materials of the connecting piping shall meet the requirements titled "Materials," above.

e. Subject to the foregoing, it is recommended that:

(1) Boat designers and manufacturers, in planning toilet installations, provide a space adequate for the safe installation of an approved device.

(2) The piping or hose connecting toilet to intake of device shall be as short and direct as possible, but should not exceed 3 feet in length.

See Recommended State Legislation for Urban Water Supply and Sewage Systems of the Public Health Service (1965) at end of Chapter X, Public Water Supply. Also see "Recommended State Legislation and Regulation for urban water supply and sewerage systems, and for well construction and individual sewage disposal systems," Public Health Service publication, July 1965.

Chapter XV

Individual Excreta and Sewage Disposal Systems

The sanitarian, much more than the engineer, is close to the country, small town, and suburban people and to their environmental hygiene needs. He often finds himself faced with the problems of proper disposal of fecal matter for rural communities, growing suburban areas, summer hotels, temporary camps of laborers, tourist camps, and summer colonies at beach and mountain resorts. Individual excreta disposal in the United States, had, up to several decades ago, been taken care of rather extensively, by the very simple manner of privies and latrines. Today these methods are elemental in the economically under-developed areas of the world. Bacteriological and geological sciences and technological development has modernized the waste disposal methods for individual households, and the great increase in family income in the United States has encouraged their use. Thus, the more satisfactory method of septic tank and disposal field has been rapidly displacing the use of the privy. A well-trained sanitarian should know the rationale and the technical procedure for the construction and operation of all types of private systems of excreta disposal and should be an efficient consultant in these matters.

Individual disposal systems have created problems:

1. Because, often, the nature of the soil is not taken into account. Different methods of disposal may be required for different types of soil and topography, and, at times, individual systems may be completely undesirable.

2. Because adequate care of the facilities is more or less disagreeable and therefore neglected.

3. Because the inherent hygienic hazards are not well enough understood nor appreciated.

4. Because, too often, subdivision developers are apt tc install individual disposal systems, although a collective system is the most economical and otherwise desirable.

5. Because the design and construction of privies appear to be so easy and simple that they are often thoughtlessly constructed.

6. Because the economic status of many rural sections is such that the cost of construction of satisfactory disposal units is often too great a financial burden, especially in depressed or economically underdeveloped areas.

7. Because plantation owners and rural landlords are often too recalcitrant to provide the health needs of tenants.

8. Because collective sanitation is more difficult of administration in areas of scattered dwellings than in urban communities.

Besides contamination of the ground or water by pathogenic organisms, such as cause typhoid fever, paratyphoid fever, dysentery, poliomyelitis, infectious hepatitis, cholera, etc., the disposal of human excreta may contaminate the ground with worms such as hookworms, ascaris, tape worm, pin worms, etc. In rural communities of the South, the hookworm is of great importance in considering the health of the people; also the ascaris worm, although not as dangerous to the health as the hookworm, it is prevalent over the entire U. S.

1. Due to migratory habits of the tenant farmers and farm laborers, they are important agents for spreading worm infections in the rural areas. Rural housing has gradually become better, but there is still a deplorable amount of rural housing units with no sanitary excreta disposal facilities.

The problem of the individual excreta and sewage disposal unit is by no means as well solved as the problem of sewage disposal in urban areas. This problem can become especially

troublesome, from a technical aspect, in lowland and swampy areas where drainage is poor and the water table is near to the surface. The great amount of relatively precise scientific knowledge that has developed in relation to public sewage disposal methods stands out in contrast to that of the relatively empirical data that has developed concerning excreta and sewage disposal for individual dwellings. The recommendations* by the "Joint Committee on Rural Sanitation," is an attempt to pool as much of the information as possible concerning individual excreta and sewage disposal. The latter recommendations are the best available and will be presented here with certain modifications.

To be safe, wastes must be disposed of so that:

1. They will not contaminate any drinking water supply.

2. They will not give rise to a public health hazard by being accessible to insects, rodents, or other possible vectors which may come into contact with food or drinking water.

3. They will not give rise to a public health hazard by being accessible to children.

4. They will not violate laws or regulations governing water pollution or sewage disposal.

5. They will not pollute or contaminate the waters of any bathing beach, shellfish-breeding ground, or stream used for public or domestic water-supply purposes, or for recreational purposes.

6. They will not give rise to a nuisance due to odor or unsightly appearance.

Water Carriage Sewage Disposal Methods:

The most satisfactory and convenient method of disposing of excretal wastes where running water is available is by a water carriage system. While this type of system allows an easy carriage of the wastes from the dwelling, the problem of final disposal is complicated by the large increase in bulk caused by the addition of water and character of the terrain.

Experience has indicated that the most efficient installation for the disposal of sewage from individual dwellings and public buildings located in sparsely settled areas where a public sewer system cannot be made available is an adequately sized septic tank with a properly designed field system for the disposal of the effluent. However, no individual design is applicable for universal adoption due to varying local conditions and types of soil encountered. Where only very restricted yard or lot areas are available, complications often develop, and in many instances seepage pits or a combination of subsurface disposal fields and seepage pits, or even cesspools with seepage pits** for effluent disposal have to be designed to meet the conditions encountered. Tight clay soils or lowland water-logged soils also offer many perplexing problems regarding the safe and satisfactory disposal of the effluent.

Where individual systems are proposed in subdivision areas which may eventually become congested areas, special care must be taken to assure the construction of the most satisfactory installation, bearing in mind the conditions which will exist when such areas are completely developed. Soil conditions must be carefully checked by percolation tests to determine the porosity. In all cases, the systems must be designed in accordance with definite recommendations in order to prevent the development of saturated soil conditions which may eventually result in public health hazards.

Suitability of Soil

When in the ground, bacteria will continue to live, dependent on the favorableness or unfavorableness of their environment, that is, the termperature, the pH, the food supply, etc. The ground is usually unfavorable for prolonged sustenance of pathogenic bacteria. Typhoid bacilli will probably live 70 days in wet soil at a pH near neutral. Paratyphoid and dysentery bacilli

* Manual of Septic Tank Practice, Public Health Service Publication No. 526, 1963.
** Some States do not allow the use of such structures.

may live somewhat longer. Coli bacilli were found to live buried in the soil for a period of over 3 years. Therefore the longer it takes contaminated water to trickle through the soil the safer it becomes. Experiments show that if a privy be sunk below the water table, the pollution may travel as far as 232 feet horizontally along the water table. They show also that the bacteria move only in the direction of the flow of the water along the water table line and not along the whole zone of saturation, and in the top layer of the moving water.

Table 1 Velocity of Underground Water According to Type of Earth

Type of Earth	Grain Size in mm.	Average Velocity-ft./day. 1% H.G.*
Silt-fine sand	0.005 to 0.25	0.065
Sand stone	0.25 to 0.50	1.16
Coarse sand	0.50 to 2.0	6.33
Gravel	2.0 to 10.0	30.00

*1% Hydraulic gradient means a slope formed by a height of one foot and a horizontal base of 100 feet.

We see, then, that the finer the porosity of the soil, the more effective it is as a filter of ground water. The porosity of the soil tends toward two extremes, very large and very small pores. In either extreme the soil becomes less and less effective and even useless. The very large pores of large gravel strata are ineffective as filters due to their inability to filter out small particles. The very small pores of lime stone strata are ineffective as filters on account of their almost imperviousness. Between these two extremes, we find a range of porosity that is suitable for filtration or as we will henceforth call it, the "percolation" of water.

The first step in the design of subsurface sewage-disposal systems is to determine whether the soil is suitable for the absorption of septic-tank effluent and, if so, how much area is required. The soil must have an acceptable percolation rate, without interference from ground water or impervious strata below the level of the absorption system. In general, two conditions must be met:

(1) The percolation time should be within the range of those specified in Table 2.

(2) The maximum elevation of the ground-water table should be at least 4 feet below the surface. Rock formations or other impervious strata should be at a depth greater than 4 feet below the bottom of trench or seepage pit.

Unless these conditions be satisfied, the site is unsuitable for a subsurface sewage-disposal system, except for isolated systems.

Percolation Tests

Subsurface explorations are necessary to determine subsurface formations in a given area. An auger with an extension handle is often used for making the investigation. In some cases, an examination of road cuts, stream embankments, or building excavations will give useful information. Wells and well-drillers' logs can also be used to obtain information on ground water and subsurface conditions. In some areas, subsoil strata vary widely in short distances, and borings must be made at the site of the system. If the subsoil appears suitable, percolation tests should be made at points and elevations selected as typical of the area in which the disposal field will be located.

The percolation tests determine the acceptability of the site and the design of the subsurface disposal system. The length of time required for percolation tests will vary in different types of soil. The safest method is to make tests in holes which have been kept filled with water for at least 4 hours, preferably overnight. This is particularly desirable if the tests are to be made by an inexperienced person, and in some soils it is necessary even if the individual has had considerable experience (as in soils which swell upon wetting). Percolation rates should be figured

on the basis of the test data obtained after the soil has had opportunity to become wetted or saturated and has had opportunity to swell for at least 24 hours. Enough tests should be made in separate holes to assure that the results are valid.

The percolation test developed at the Robert A. Taft Sanitary Engineering Center incorporates these principles. Its use is particularly recommended when knowledge of soil types and soil structure is limited. When previous experience and information on soil characteristics are available, some persons prefer other percolation test procedures, such as those developed by Kiker and by Ludwig.*

Procedure for Percolation Tests (Developed at Robert A. Taft Sanitary Engineering Center):

1. Number and location of test. -- Six or more tests shall be made in separate test holes spaced uniformly over the proposed absorption-field site.

2. Type of test hole. --Dig or bore a hole, with horizontal dimensions of from 4 to 12 inches and vertical sides to the depth of the proposed absorption trench. In order to save time, labor, and volume of water required per test, the holes can be bored with a 4-inch auger. (See Fig. 1)

3. Preparation of test hole. -- Carefully scratch the bottom and sides of the hole with a knife blade or sharp-pointed instrument, in order to remove any smeared soil surfaces and to provide a natural soil interface into which water may percolate. Remove all loose material from the hole. Add 2 inches of coarse sand or fine gravel to protect the bottom from scouring and sediment.

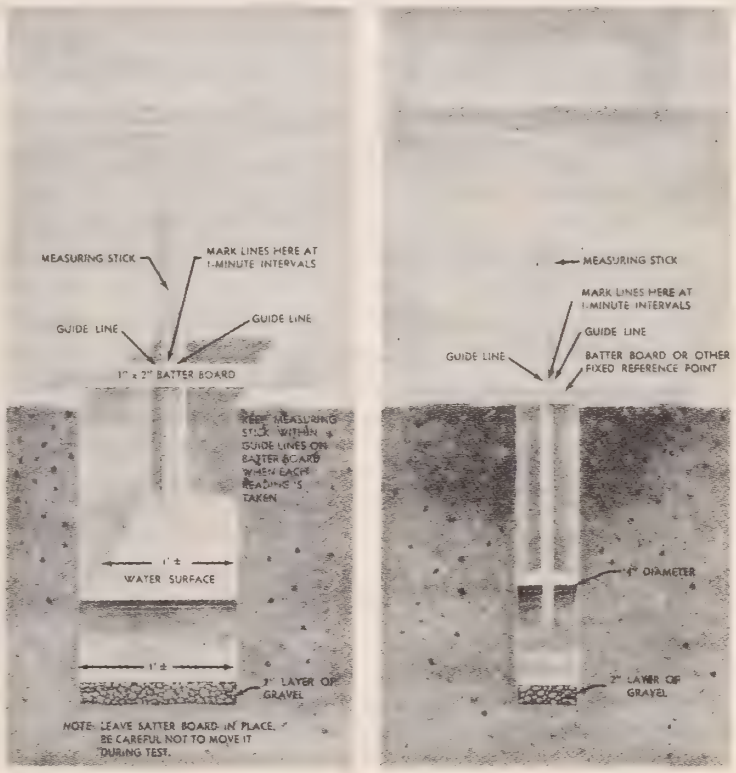

MEASURING STICK
MARK LINES HERE AT 1-MINUTE INTERVALS
GUIDE LINE
GUIDE LINE
1" x 2" BATTER BOARD
KEEP MEASURING STICK WITHIN GUIDE LINES ON BATTER BOARD WHEN EACH READING IS TAKEN
1" ±
WATER SURFACE
1" ±
2" LAYER OF GRAVEL
NOTE: LEAVE BATTER BOARD IN PLACE. BE CAREFUL NOT TO MOVE IT DURING TEST.
MEASURING STICK
MARK LINES HERE AT 1-MINUTE INTERVALS
GUIDE LINE
GUIDE LINE
BATTER BOARD OR OTHER FIXED REFERENCE POINT
4" DIAMETER
2" LAYER OF GRAVEL

Figure 1. --Absorption area requirements for private residences.

4. Saturation and swelling of the soil. -- It is important to distinguish between saturation and swelling. Saturation means that the void spaces between soil particles are full of water. This can be accomplished in a short period of time. Swelling is caused by intrusion of water into the individual soil particle. This is a slow process, especially in clay-type soil, and is the reason for requiring a prolonged soaking period.

In the conduct of the test, carefully fill the hole with clear water to a minimum depth of 12 inches over the gravel. In most soils, it is necessary to refill the hole by supplying a surplus reservoir of water, possibly by means of an automatic syphon, to keep water in the hole for at least 4 hours and preferably overnight. Determine the percolation rate 24 hours after water is first added to the hole. This procedure is to insure that the soil is given ample opportunity to swell and to approach the condition it will be in during the wettest season of the year. Thus, the test will give comparable results in the same soil, whether made in a dry or in a wet season. In sandy soils containing little or no clay, the swelling procedure is not essential, and the

*Manual of Septic Tank Practice, Public Health Service Publication No. 526, pp. 66-70.

test may be made as described under item 5C below, after the water from one filling of the hole has completely seeped away.

5. Percolation-rate measurement. -- With the exception of sandy soils, percolation-rate measurements shall be made on the day following the procedure described under item 4, above.

A. If water remains in the test hole after the overnight swelling period, adjust the depth to approximately 6 inches over the gravel. From a fixed reference point, measure the drop in water level over a 30-minute period. This drop is used to calculate the percolation rate.

B. If no water remains in the hole after the overnight swelling period, add clear water to bring the depth of water in the hole to approximately 6 inches over the gravel. From a fixed reference point, measure the drop in water level at approximately 30-minute intervals for 4 hours, refilling 6 inches over the gravel as necessary. The drop that occurs during the final 30-minute period is used to calculate the percolation rate. The drops during prior periods provide information for possible modification of the procedure to suit local circumstances.

C. In sandy soils (or other soils in which the first 6 inches of water seeps away in less than 30 minutes, after the overnight swelling period), the time interval between measurements shall be taken as 10 minutes and the test run for 1 hour. The drop that occurs during the final 10 minutes is used to calculate the percolation rate.

Table 2 Absorption-area requirements for private residences
(Provides for Garbage-Grinder and Automatic-Sequence Washing Machines)

Percolation rate (Time required for water to fall 1 inch, in minutes)	Required absorption area, in square feet per bedroom[1] standard trench,[2] seepage beds, and seepage pits[3]	Percolation rate (Time required for water to fall 1 inch, in minutes)	Required absorption area, in square feet per bedroom[1] standard trench[2] and seepage pits[3]
1 or less	70	10	165
2	85	15	190
3	100	30[4]	250
4	115	45[4]	300
5	125	60[4,5]	330

1. In every case, sufficient area should be provided for at least 2 bedrooms.
2. Absorption area is figured as trench-bottom area.
3. Absorption area for seepage pits is figured as effective side-wall area beneath the inlet.
4. Unsuitable for seepage pits if over 30.
5. Unsuitable for leaching systems if over 60.

Guide for Estimating Soil-Absorption Potential

Deep sands and loessial soils of considerable depth can be segregated from clays and clay loams, with the advantage that the sands and deep loessial silt loams, in all likelihood, will give little trouble in the design of septic-tank systems. It is at the other end of the spectrum of soil permeability (i.e., clays and clay loams) that problems will commonly arise, and it is in this range that careful measurements of absorption capacity are especially needed. Clues are useful in broadly identifying problem soils, but they cannot indicate precise absorption rates.

Soil Maps. -- The capacity of a soil to absorb and transmit water is an important problem in agriculture, particularly in relation to irrigation, drainage, and other land-management practices. Through studies in these fields, a variety of aids have been developed for judging the absorption of water-transmission properties of soils, which could be helpful in the sewage field. Considerable information has been accumulated by agricultural authorities on the relative absorption capacities of specific soils in many areas of the United States. Much of this information

is included in Soil Survey Reports and Maps published by the United States Department of Agriculture in cooperation with the various State agricultural colleges. The general suitability of specific soils for effluent disposal may often be interpreted from these reports and maps.

Clues to Absorption Capacity. -- Considerable information about relative absorption capacities of soils may also be obtained by a close visual inspection of the soil. The value of such an inspection depends upon some knowledge of the pertinent soil properties. The main properties indicative of absorption capacity are soil texture, structure, color, depth of thickness of permeable strata, and swelling characteristics.

Texture. -- Soil texture, the relative proportion of sand, silt, and clay, is the most common clue to water-absorption capacity. The size and distribution of particles govern the size and distribution of pores which, in turn, govern the absorption capacity. The larger the soil particles, the larger are the pores and the faster is the rate of absorption.

Texture can best be judged by the feel. The lighter or sandier soils have a gritty feel when rubbed between the thumb and forefinger; silty-type soils have a "floury" feel and, when wetted, have no cohesion; heavier, clay-type soils are dense and hard when dry, and have a slick greasy feel when wetted.

The use of texture as a clue to absorption qualities has its limitations; it is primarily reliable in the sandier soils. In the heavier-type soils, including sandy soils containing appreciable amounts of silt or clay, one must look for additional clues, such as structure and soil color, as indicators of absorption capacity.

Structure. -- Soil structure is characterized by the aggregation or grouping together of textural particles, forming secondary particles of larger size. Such secondary particles then tend to govern the size and distribution of pores and in turn, the absorption properties. Structure can easily be recognized by the manner in which a clod or lump breaks apart. If a soil has structure, a clod will break with very little force, along well-defined cleavage planes, into uniformly sized and shaped units. If a soil has no structure, a clod will require more force to break apart and will do so along irregular surfaces, with no uniformity in size and shape of particles.

In general, there are four fundamental structure types, named according to the shape of the aggregate particles: Platy, prism-like, block-like, and spheroidal. A soil without structure is generally referred to as massive. Spheroidal structure tends to provide the most favorable absorption properties, and platy structure, the least. Although other factors, such as size and stability of aggregates to water, also influence the absorption capacity. Recognition of the type of structure is probably sufficient for a general appraisal.

Color. -- One of the most important practical clues to water absorption is soil color. Most soils contain some iron compounds. This iron, like iron in a tool or piece of machinery, if alternately exposed to air and to water, oxidized and takes on a reddish-brown to yellow color. Thus, if a soil has uniform reddish-brown to yellow oxidized color, it indicates that there has been free alternate movement of air and water in and through the soil. Such a soil has desirable absorption characteristics. At the other extreme are soils of a dull-gray or mottled coloring, indicating lack of oxidizing conditions or very restricted movement of air and water. These soils have poor absorption characteristics.

Depth or Thickness of Permeable Strata. -- The quantity of water that may be absorbed is proportional to the thickness or volume of the absorbent stratum, when all other conditions are alike. In a soil having a foot or more of permeable material above tight clay, absorption capacity is far greater than that of the same kind of material lying within 3 inches of tight clay. When examining soils or studying soil descriptions, the depth and thickness, therefore, are important criteria of absorption capacity.

Swelling Characteristics. -- Most, but not all, clays swell upon the addition of moisture. There are many clays (in the tropics, in particular) that do not swell appreciably. There are

also some soils in the United States which do not swell noticeable. On the other hand, some soils have a very high percentage of swelling, and these in particular must be suspect. Relative swelling of different soils is indicated by relative shrinkage when dry, as shown by the numbers and sizes of cracks that form. Those that shrink appreciably when dry are soils that may give trouble in a tile field when they are wet.

Information obtained through inspection or from soil maps and reports can be of particular value in preliminary appraisal of soils for sewage disposal. For instance, in many cases, unsuitable soils may be immediately ruled out on the basis of such information; in other cases, selection of the best of several sites may be made on the basis of the inspection. Absorption-capacity information obtained in this manner is relative. For quantitative information upon which to base specific design, we still must depend on some direct measurement, such as a water-absorption rate as measured by a percolation test.

Use of Polyelectrolytes

Synthetic polyelectrolytes have been used to improve the filterability of the tight soils, and there has been much speculation concerning their use in subsurface sewage-disposal systems. Studies have demonstrated that the use of polyelectrolytes will greatly increase the permeability of clay soils for short periods of time, but that the cost of such treatment for disposal areas would be prohibitive in most cases. At prices prevailing in 1954, the cost of polyelectrolyte alone would increase the cost of an ordinary trench by $3.50 per foot under the conditions studied. Furthermore, it was found that the effective life of the material, measured by the length of time a high percolation rate was sustained, was only a few weeks or months in a sewage-absorption system. This compares with an effective life of two or three years as reported for the usefulness of single application for agricultural purposes.

Curtain Drains for Absorption Trench Systems

Even though proper precautions are taken to ascertain the maximum ground-water table before the absorption-trench method of sewage-effluent disposal is approved for a given area, instances occur where the height of a water table rises above that indicated by past performances and observations. This may lead to failure of the disposal system.

It is sometimes possible to rehabilitate such a system by constructing around the disposal area a curtain drain designed to intercept the superficial ground water and carry it away from the area. If the absorption field be on sloping ground, a single drain at the upper end of the area may be sufficient. Where open curtain drains are not feasible, rock-filled trenches above or around the disposal area may sometimes be used. In either case, it is necessary to have a suitable outlet for the ground water that is intercepted.

Leaching System

For areas where the percolation rates are good, the next step after making the percolation tests is to determine the required absorption area from Table 2 or Figure 2 and to select the leaching system that will be satisfactory for the area in question. As noted in Table 2, soil in which the percolation rate is slower than 1 inch in 30 minutes is unsuitable for seepage pits, and that slower than 1 inch in 60 minutes is unsuitable for any type of soil-absorption disposal system. Therefore, such areas should not be used until or unless suitable alternate facilities be available.

The selection of the leaching system will be dependent to some extent on the location of the system in the area under consideration. A safe distance should be maintained between the site and any source of water supply. Since the distance that pollution will travel underground depends upon numerous factors, including the characteristics of the subsoil formations and the quantity of sewage discharged, it is not practical to specify minimum distances that would be reasonable in all localities. Ordinarily, of course, the greater the distance, the greater will be the safety provided. In general, all subsurface absorption systems should be kept 100 feet from any water-supply well, 50 feet from any stream or watercourse, and 10 feet from dwellings or property lines. Seepage pits should not be used in areas where domestic water supplies are obtained from shallow wells, or where there are limestone formations and sink-holes with connection to underground channels through which pollution may travel to water sources. Seepage pits should not be located within 20 feet of any dwelling or property line.

Details pertaining to local water wells, such as depth, type of construction, vertical zone of influence, etc., together with data on the geological formations and porosity of subsoil strata, should be considered in determining the safe allowable distance between wells and subsurface disposal systems.

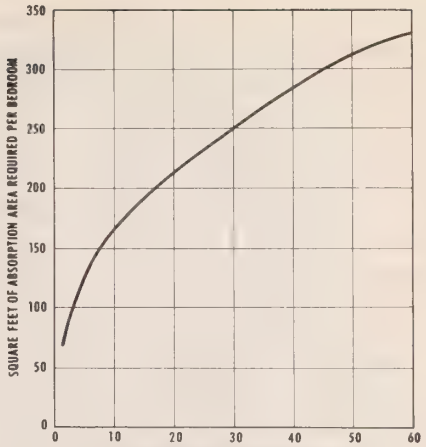


Figure 2.--Absorption area requirements for private residences.

Standard Trenches

An absorption field or subsurface tile system consists of a field of 12-inch lengths of 4-inch agricultural drain tile, 2- to 3-foot lengths of vitrified-clay sewer pipe, or perforated, nonmetallic pipe, laid in such a manner that flow from the septic tank will be distributed with reasonable uniformity into natural soil. The individual laterals preferably should not be over 60 feet long, with a maximum length of 100 feet, and the trench bottom and tile distribution lines should be laid at a grade of 2 to 4 inches per 100 feet and never to exceed 6 inches per 100 feet. Use of more and shorter laterals is preferred because if something should happen to disturb one line, most of the field will still be serviceable.

A typical layout is illustrated in Figures 3 and 4. Enlarged details or sections of a trench are shown in Figure 5.

Table 3. -- Distances between trenches

Trench width, inches	Minimum distance between centerline of trenches, feet	Trench width, inches	Minimum distance between centerline of trenches, feet
12 to 18 ----------	6	24 to 30 ----------	7.0
18 to 24 ----------	6.5	30 to 36 ----------	7.5

Table 4 Minimum Standards For Disposal Field Construction

Disposal-field construction	Minimum Standard
Lines per field, minimum number ----------	2
Individual lines, maximum length ----------	100 ft.
Trench bottom, minimum width ----------	18 in.
Field tile, minimum diameter ----------	4 in.
Field-tile lines, maximum slope ----------	6 in. in 100 ft.
Field trenches, minimum separation ----------	6 ft.
Effective absorption area, minimum per dwelling unit	

The depth of the absorption-field trenches should be at least 18 inches. Additional depth may be needed for contour adjustment, extra aggregate under the tile, or other design purposes. In considering the depth of the absorption-field trenches, the possibility of tile lines freezing during prolonged cold period is raised. Freezing rarely occurs in a carefully constructed system kept in continuous operation. It is important during construction to assure that the tile lines are surrounded by gravel. Pipes under driveways or other surfaces which are usually cleared of snow should be insulated.

The required absorption area is predicated on the results of the soil-percolation test, and may be obtained from column 2 of Table 2 or Figure 2. Note especially that the area requirements are per bedroom. Thus for a 3-bedroom house on a lot where the minimum perco-

lation rate was 1 inch in 15 minutes, the necessary leaching trench area will be 3 x 190 sq. feet, or 570 square feet. For trenches 2 feet wide with 6 inches of gravel below the drain tile, the required total length of trench would be 570 ÷ 2, or 285 feet. If this were divided into 5 portions (i.e., 5 laterals), the length of each line would be 285 ÷ 5, or 57 feet. The minimum spacing between tile lines may vary between 6 to 7.5 feet, depending on the selected width of trench (Table 3). In the example cited, a minimum lateral spacing of 6.5 feet should be used. The minimum total area for the absorption field required would equal 5 x 6.5 x 57 = 1,852 square feet.

Attention should be given to the protection of the natural absorption properties of the soil. Care must be taken to prevent sealing of the surface on the bottom and sides of the trench. Trenches should not be excavated when the soil is wet enough to smear or compact easily. Soil moisture is right for safe working only when a handful will mold with considerable pressure. Open trenches should be protected from surface runoff to prevent the entrance of silt and debris. If it be necessary to walk in the trench, a temporary board laid on the bottom will reduce the damage. Some smearing and damage is bound to occur. All smeared or compacted surfaces should be raked to a depth of 1 inch, and loose material removed, before the gravel is placed in the trench.

The tile, laid in a trench of sufficient width and depth, should be surrounded by clean, graded gravel, broken brick, washed rock, or similar aggregate. Where an acceptable method of distribution other than open jointed tile or perforated pipe is used, provision such as depth of rock fill or packing material with reference to tile or pipe are not applicable. The material may range in size from 1/2-inch to 2-1/2 inches. Cinders, broken shell, and similar material are not recommended, because they are usually too fine and may lead to premature clogging (of perforations). The material should

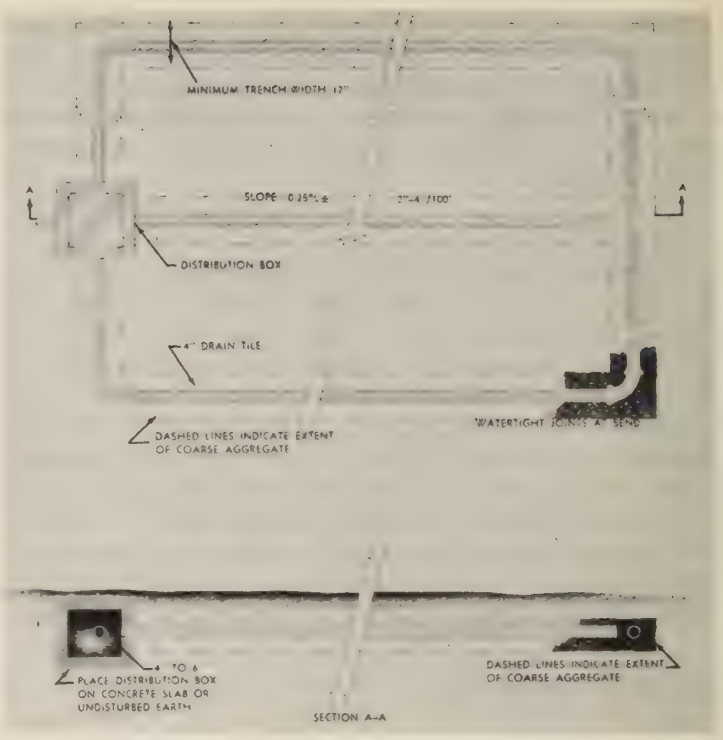

MINIMUM TRENCH WIDTH 12"
SLOPE 0.25%±
2"-4'/100'
DISTRIBUTION BOX
4" DRAIN TILE
WATERTIGHT JOINTS AT SEND
DASHED LINES INDICATE EXTENT OF COARSE AGGREGATE
4" TO 6"
PLACE DISTRIBUTION BOX ON CONCRETE SLAB OR UNDISTURBED EARTH
DASHED LINES INDICATE EXTENT OF COARSE AGGREGATE
SECTION A-A

Figure 3. --Absorption-field system for level ground.

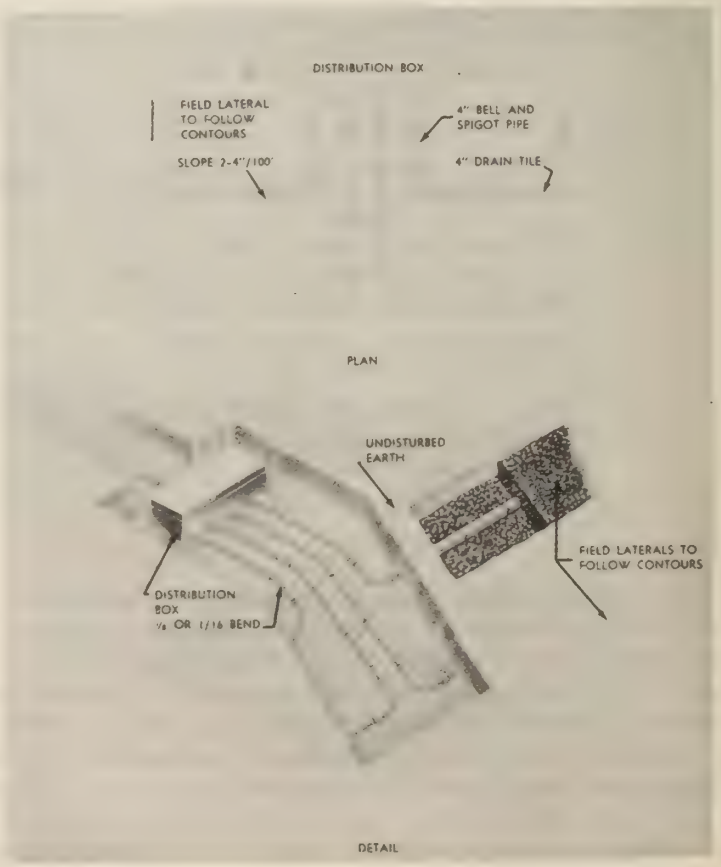


Figure 4. --Absorption-field system for sloping ground.

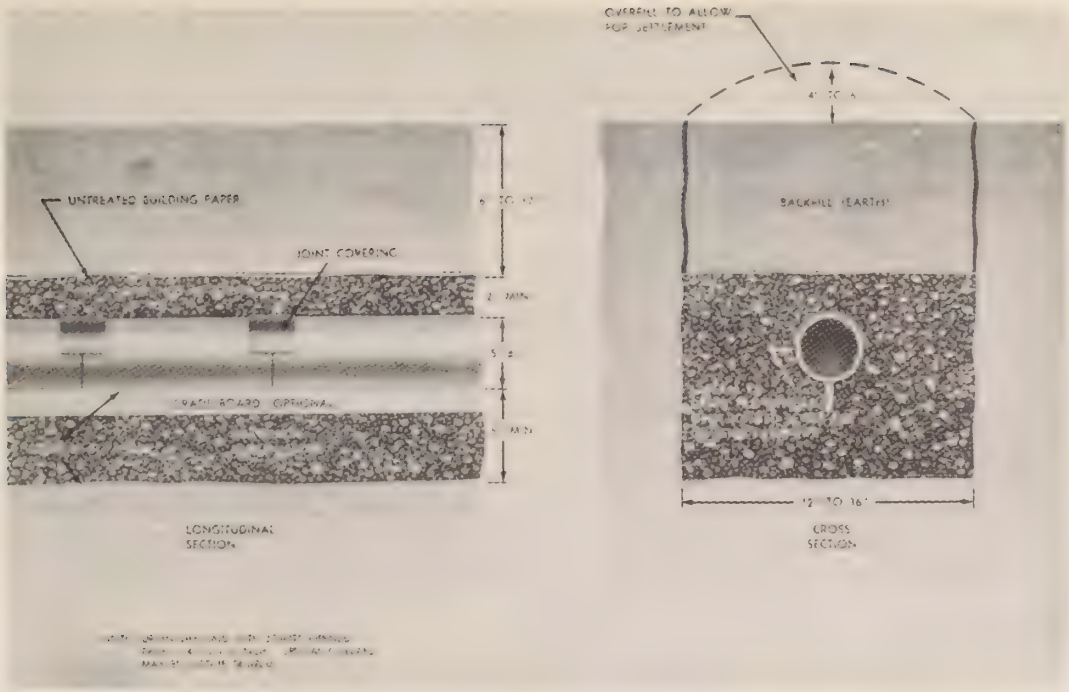


Figure 5. --Absorption trench and lateral.

extend from at least 2 inches above the top of the tile to at least 6 inches below the bottom of the tile. The upper half of the joint openings should be covered, as shown in Figure 5. The top of the stone should be covered with untreated building paper or a 2-inch layer of hay, straw, pine needles, or similar material before placing the earth backfill. This will help prevent the stone from becoming clogged with the earth backfill. An impervious covering should not be used, as this interferes with evapotranspiration* at the surface. Although generally not figured in the calculations, evapotranspiration is often an important factor in the operation of horizontal leaching systems.

Drain-tile connectors, collars, clips, or other spacers with covers for the upper half of the joints are of value in obtaining uniform spacing, proper alignment, and protection of tile joints, but use of such aids is optional. They have been made of galvanized iron, copper, and plastic.

It has been found that root problems may be prevented best by using a liberal amount of gravel or stone around the tile. Clogging due to roots has occurred mostly in lines with insufficient gravel under the tile. Furthermore, roots seek the location where moisture conditions are most favorable for growth and, in the small percentage of cases where they become troublesome in well-designed installations, there is usually some explanation involving the moisture conditions. At a residence which is used only during the summer, for example, roots are most likely to penetrate when the house is uninhabited, or when moisture immediately below or around the gravel becomes less plentiful than during the period when the system is in use. In general, trenches constructed within 10 feet of large trees or dense shrubbery should have at least 12 inches of gravel or crushed stone beneath the tile.

The top of a new absorption trench should be hand-tamped and should be overfilled with about 4 to 6 inches of earth. Unless this be done, the top of the trench may settle to a point lower than the surface of the adjacent ground. This will cause the collection of storm water in the trench,

* The action of trees, shrubs, and grasses in the absorption and subsequent release to the atmosphere of appreciable quantities of moisture.

which can lead to premature saturation of the absorption field and possibly to complete washout of the trench. Machine tamping or hydraulic backfilling of the trench should be prohibited.

Where sloping ground is used for the disposal area, it is usually necessary to construct a small temporary dike or surface-water diversion ditch above the field to prevent the disposal area from being washed out by rain. The dike should be maintained or the ditch kept free of obstructions until the field becomes well covered with vegetation.

A heavy vehicle would readily crush the tile in a shallow absorption field. For this reason, heavy machinery should be excluded from the disposal area unless special provision be made to support the weight. All machine grading should be completed before the field is laid.

Seepage Beds

Common design practice for soil absorption fields for private residences provides for trench widths varying from 12 to 36 inches. Variations of design utilizing increased width are being used in many areas. Absorption systems having trenches wider than 3 feet are referred to as seepage beds. The design of trenches is based on an empirical relationship between the percolation test and the bottom area of the trenches. The use of seepage beds has been limited by the lack of experience with their performance and the absence of design criteria comparable to that for trenches.

Recent studies sponsored by the Federal Housing Administration have demonstrated that the seepage bed is a satisfactory device for disposing of effluent in soils that are acceptable for soil absorption systems. The studies have further demonstrated that the empirical relationship between the percolation test and bottom area required for trenches is applicable for seepage beds.

There are three main elements of a seepage bed: absorption surface, rock fill or packing material, and the distribution system. The design of the seepage bed should be such that the total intended absorption area is preserved, sufficient packing material is provided in the proper place to allow for further treatment and storage of excess liquid, and a means for distributing the effluent is protected against siltation of earth backfill and mechanical damage. Construction details for a conventional seepage bed are outlined in the following material in such a way that these principal design elements are incorporated. Tabulation of construction details for the conventional seepage bed is not intended to preclude other designs which may provide the essential features in a more economical or otherwise desirable manner. Specifically, there may be equally acceptable or even superior methods developed for distributing the liquid than by the tile or perforated pipe covered with gravel.

The use of seepage beds results in the following advantages:

1. A wide bed makes more efficient use of land available for absorption systems than a series of long narrow trenches with wasted land between the trenches.

2. Efficient use may be made of a variety of modern earth-moving equipment employed at housing projects for other purposes such as basement excavation and landscaping, resulting in savings on the cost of the system.

Recommended Modifications of Absorption Field Design

When seepage beds are used, the following design and construction procedures, providing for rock fill or packing material, an adequate distribution system, and protection of the absorption area, should be observed:

1. The amount of bottom absorption area required shall be the same as shown in table 2.

2. Percolation tests should be conducted as already described.

3. The bed should have a minimum depth of 24 inches below natural ground level to provide a minimum earth backfill cover of 12 inches.

4. The bed should have a minimum depth of 12 inches of rock fill or packing material extending at least 2 inches above and 6 inches below the distribution pipe.

5. The bottom of the bed and distribution tile or perforated pipe should have a relatively level grade.

6. Lines for distributing effluent shall be spaced not greater than 6 feet apart and not greater than 3 feet from the bed sidewall.

7. When more than one bed is used:
   a. there should be a minimum of 6 feet of undisturbed earth between adjacent beds; and
   b. the beds should be connected in series as indicated for serial distribution.

Distribution Boxes

A distribution box has, in the past, been considered essential for every absorption-field system. We are not so sure about this today. The purpose of the box is to insure equal distribution of effluent to the several lateral lines, although, the need for equal distribution is questionable. In the conventional field, especially on sloping ground, the box is necessary to prevent overloading and failure of one line while the others are left empty. Pipe fittings, tees, and wyes have been proposed for this purpose, but to obtain even distribution with them is a rare event, if not a virtual impossibility. At least two lateral lines should lead from the box, and enough additional laterals should be connected to the box to provide the required effective percolation area. The design of the system can be varied to meet most topographical conditions encountered, while giving proper grade and alignment for all laterals (figure 4). Typical distribution boxes and location are shown in figures 4, 6 and 7.

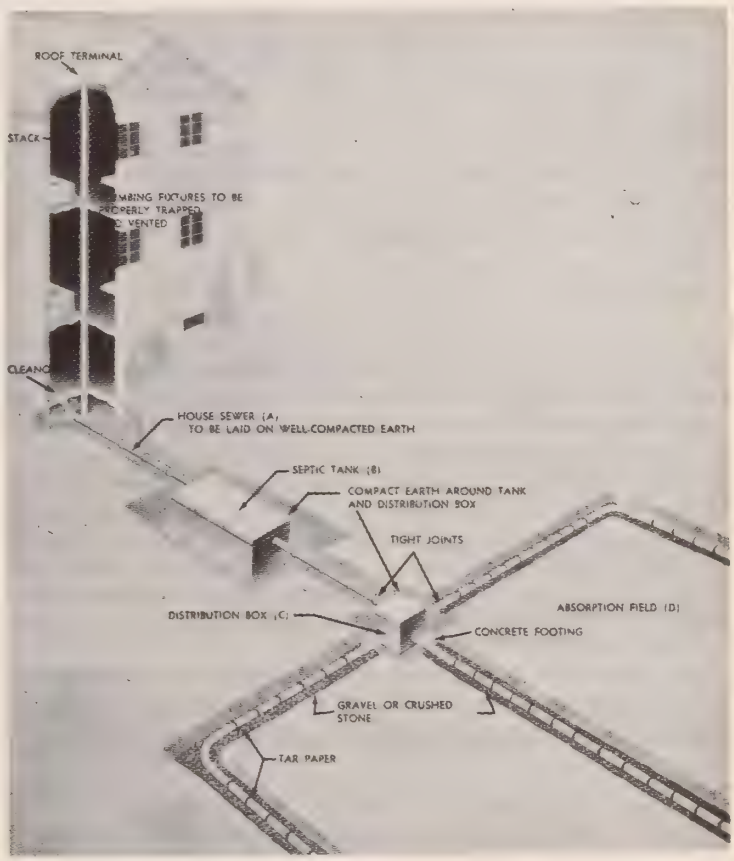


Figure 6. --Septic-tank sewage-disposal system.

Serial Distribution Systems

Recent studies sponsored by the Federal Housing Administration have demonstrated that various arrangements in the tile field, including the distribution box, do not achieve uniform distribution. Furthermore, it has never been established that equal distribution has any advantages as opposed to some arrangement of serial distribution. Serial distribution is achieved by arranging individual trenches of the absorption system so that each trench is forced to pond to the full depth of the gravel fill before liquid flows into the succeeding trench. In this manner, the total absorption area of the entire system is utilized before ultimate failure can occur.

Serial distribution has the following advantages:

1. It minimizes the importance of variable absorption rates by forcing each trench to absorb effluent until its ultimate capacity is utilized. The variability of soils even in the small area of an individual absorption field raises doubt of the desirability of uniform distribution. Any one or a combination of factors may lead to non-uniform absorptive capacity of the several trenches

in a system. Varying physical and chemical characteristics of the soil, construction damage such as soil interface smearing or excessive compaction, poor surface drainage, and variation in depth of trenches are some of the factors involved.

2. It causes each trench in the absorption system to be used to full capacity before failure occurs. It has a distinct advantage on sloping terrain. With imperfect division of flow in a parallel system, one trench could become overloaded, resulting in a surcharged condition. If the slope of the ground and elevation of the distribution box were such that a surcharged trench continued to receive more effluent than it could absorb, local failure would occur before the full capacity of the system was utilized.

3. The cost of the distribution box is eliminated in serial distribution. Also, long runs of closed pipe connecting the box to each trench are unnecessary.

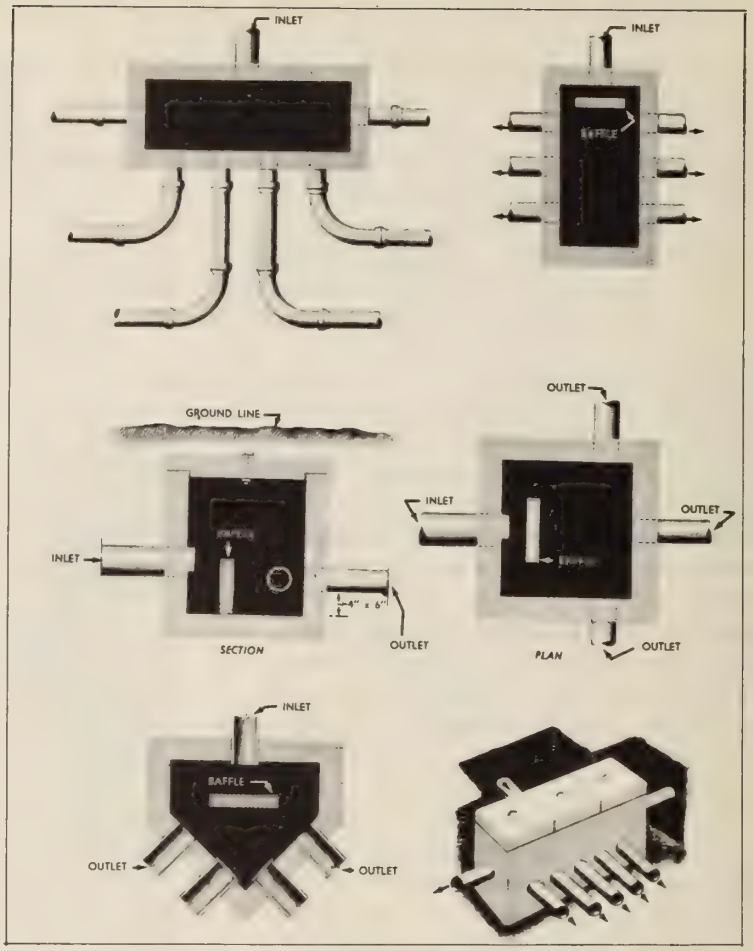


Figure 7. --Distribution boxes.

Recommended Modifications of Absorption Field Design

Fields in Flat Areas:

Where the slope of the ground surface does not exceed six inches in any direction within the area utilized for the absorption field, the septic tank effluent may be applied to the absorption field through a system of inter-connected tile lines and trenches in a continuous system. The following specific criteria should be followed:

1. A minimum of 12 inches of earth cover is provided over the gravel fill in all trenches of the system.

2. The bottom of the trenches and the distribution lines are constructed on a relatively level grade.

3. Other construction features of the disposal field are the same as previously described. A satisfactory absorption system layout for "level" ground is shown in Figure 8.

Fields in Sloping Ground:

Serial distribution may be used in all situations where a soil absorption system is permitted and should be used where the fall of the ground surface exceeds approximately 6 inches in any direction within the area utilized for the absorption field. The maximum ground slope suitable for serial distribution systems should be governed by local factors affecting the erosion of the ground used for the absorption field. Excessive slopes which are not protected from surface water runoff or do not have adequate vegetation cover to prevent erosion should be avoided. Generally, ground having a slope greater than one vertical to two horizontal should be investigated carefully to determine if satisfactory from the erosion standpoint. Also, the horizontal

distance from side of the trench to the ground surface should be adequate to prevent lateral flow of effluent and breakout on surface.

In serial distribution, each adjacent trench (or pair of trenches) is connected to the next by a closed pipe line laid on an undisturbed section of ground, as shown in Figure 9. The arrangement is such that all effluent is discharged to the first trench until it is filled. Excess liquid is then carried by means of a closed line to the next succeeding or lower trench. In that manner, each portion of the subsurface system is used in succession. When serial distribution is used, the following design and construction procedures should be followed:

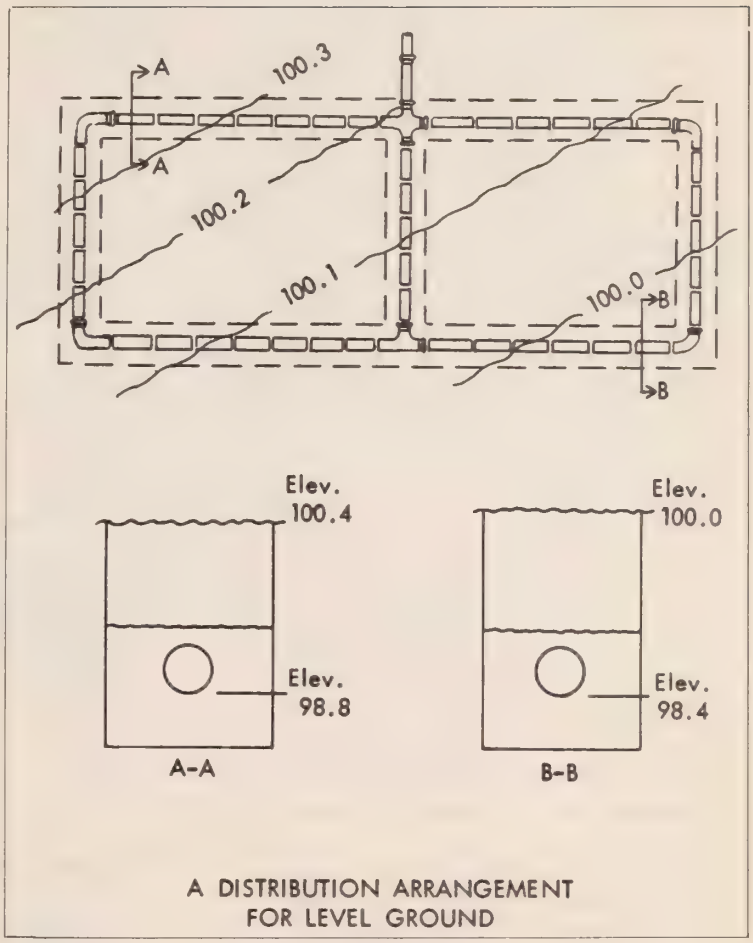


Figure 8

1. The amount of absorption area required shall be the same as shown in table 2.

2. The bottom of each trench and its distribution line should have a relatively level grade.

3. There should be a minimum of 12 inches of ground cover over the gravel fill in the trenches.

4. The absorption trenches should follow approximately the ground surface contours so that variations in trench depth will be minimized.

5. There should be a minimum of 6 feet of undisturbed earth between adjacent trenches, and between the septic tank and the nearest trench.

6. Adjacent trenches may be connected with the relief line or a drop box arrangement (Fig. 9) in such a manner that each trench is completely filled with septic tank effluent to the full depth of the gravel before effluent flows to succeeding trenches. (The illustrations shown do not preclude the use of other arrangements to provide serial distribution.)

a. Trench connecting lines should be 4-inch tight-joint sewers with direct connections to the distribution lines in adjacent trenches or to a drop box arrangement.

b. Care must be exercised in constructing relief lines to insure an undisturbed block of earth between trenches. The trench for the relief pipe, where it connects with the preceding absorption trench, shall be dug no deeper than the top of the gravel. The relief line should rest on undisturbed earth and backfill should be carefully tamped.

c. The relief lines connecting individual trenches should be as far from each other as practicable in order to prevent short-circuiting.

7. Invert of the overflow pipe in the first relief line must be at least 4 inches lower than the invert of the septic tank outlet (Fig. 9).

8. All other construction features of the disposal field are the same as previously recommended.

Inspection

After a subsurface sewage disposal system has been installed and before it is used, the entire system should be tested and inspected. The septic tank should be filled with water and allowed to stand overnight to check for leaks. If leaks occur, they should be repaired. The distribution box and absorption field should be checked before the laterals are covered, to be sure that the disposal system is installed properly. Inspection before backfilling should be required by local regulations, even where approval of plans for the subsurface sewage-disposal system has been required before issuance of a building permit.

Seepage Pits

A seepage pit is a covered pit with open-jointed lining through which the septic-tank effluent may seep or leach into the surrounding porous soil. It is usually considered a less-desirable method of disposal than the absorption field. Seepage pits should never be used where there is a likelihood of contaminating underground waters, not where adequate subsurface disposal fields can be provided. When seepage pits are to be used in place of a subsurface tile field, the pit excavation should terminate 4 feet above the ground-water table.

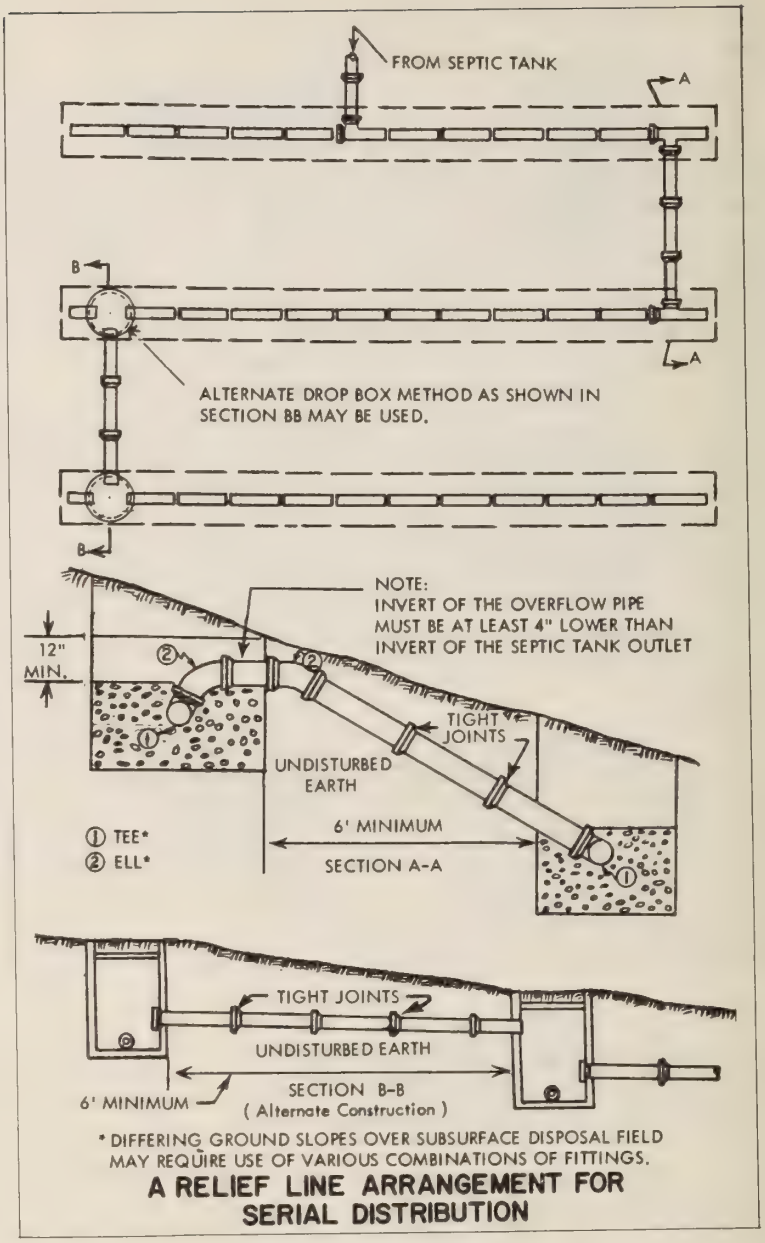

FROM SEPTIC TANK
A
B
A
ALTERNATE DROP BOX METHOD AS SHOWN IN SECTION BB MAY BE USED.
B
NOTE:
INVERT OF THE OVERFLOW PIPE MUST BE AT LEAST 4" LOWER THAN INVERT OF THE SEPTIC TANK OUTLET
12" MIN.
TIGHT JOINTS
UNDISTURBED EARTH
① TEE*
② ELL*
6' MINIMUM
SECTION A-A
TIGHT JOINTS
UNDISTURBED EARTH
6' MINIMUM
SECTION B-B
(Alternate Construction)
* DIFFERING GROUND SLOPES OVER SUBSURFACE DISPOSAL FIELD MAY REQUIRE USE OF VARIOUS COMBINATIONS OF FITTINGS.
A RELIEF LINE ARRANGEMENT FOR SERIAL DISTRIBUTION

Figure 9

In some States, seepage pits are permitted as an alternative when absorption fields are impracticable, and where the top 3 or 4 feet of soil is underlaid with porous sand or fine gravel and the subsurface conditions are otherwise suitable for pit installations. Where circumstances permit, seepage pits may be either supplemental or alternative to the more shallow absorption fields. When seepage pits are used in combination with absorption fields, the leaching areas in each system should be prorated, or based upon the weighted average of the results of the percolation tests.

It is important that the capacity of a seepage pit be computed on the basis of percolation tests made in each vertical stratum penetrated. The weighted average of the results should be computed to obtain a design figure. Soil strata in which the percolation rates are in excess of 30 minutes per inch should not be included in computing the absorption area. As will be apparent from Figure 10, adequate tests for deep pits are somewhat difficult to make, time consuming, and expensive. Although few data have been collected comparing percolation test results with deep-pit performance, nevertheless the results of such percolation tests, while of limited value, combined with competent engineering judgment based on experience, are the best means of arriving at design data for seepage pits.

Table 2 or Figure 2 gives the absorption-area requirements per bedroom for the percolation rate obtained. The effective area of the seepage pit is the vertical-wall area (based on dug diameter) of the pervious strata below the inlet. No allowance should be made for impervious strata or bottom area. With this in mind, Table 5 may be used for determining the effective side-wall area of circular or cylindrical seepage pits.

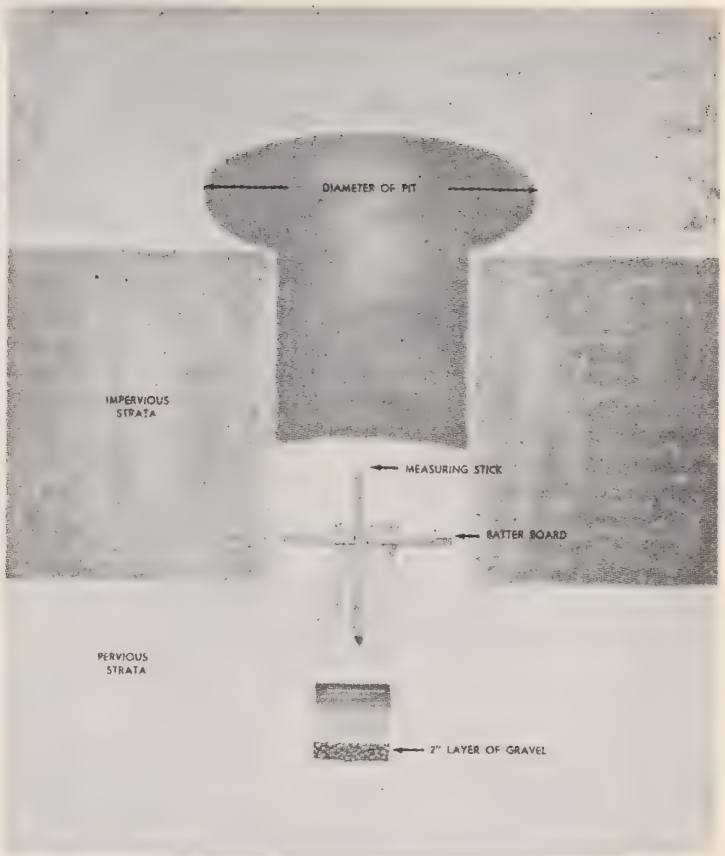


Figure 10.—Deep percolation test for seepage pit.

Table 5 -- Vertical-wall areas of round seepage pits
(In square feet)

Diameter of leaching pit (feet)	Effective strata depth below flow line (below inlet)									
	1 foot	2 feet	3 feet	4 feet	5 feet	6 feet	7 feet	8 feet	9 feet	10 feet
3 -------	9.4	19	28	38	47	57	66	75	85	94
4 -------	12.6	25	38	50	63	75	88	101	113	126
5 -------	15.7	31	47	63	79	94	110	126	141	157
6 -------	18.8	38	57	75	94	113	132	151	170	188
7 -------	22.0	44	66	88	110	132	154	176	198	220
8 -------	25.1	50	75	101	126	151	176	201	226	251
9 -------	28.3	57	85	113	141	170	198	226	254	283
10 ------	31.4	63	94	126	157	188	220	251	283	314
11 ------	34.6	69	104	138	173	207	242	276	311	346
12 ------	37.7	75	113	151	188	226	264	302	399	377

Example: A pit of 5-foot diameter and 6-foot depth below the inlet has an effective area of 94 square feet. A pit of 5-foot diameter and 16-foot depth has an area of 94 +157, or 251 square feet.

Sample Calculations

Assume that a seepage-pit leaching system is to be designed for a 3-bedroom home on a lot where the minimum percolation rate of 1 inch in 15 minutes prevails. According to Table 2,

3 x 190 (or 570) square feet of absorption area would be needed. Assume also that the water table does not rise above 27 feet below the ground surface, that seepage pits with effective depth of 20 feet can be provided, and that the house is in a locality where it is common practice to install seepage pits of 5-feet diameter (i.e., 4 feet to the outside walls, which are surrounded by about 6 inches of gravel). Design of the system is as follows:

Let x = depth of pit in feet; D = pit diameter in feet:

$$\pi Dx = 570 \text{ square feet.}$$
$$3.14\ (5)(x) = 570 \text{ square feet.}$$

Solving for x, depth of pit = 36 feet (approx.)

In other words, one 5-foot-diameter pit 36 feet deep would be needed, but since the maximum effective depth is 20 feet in this particular location, it will be necessary to increase the diameter of the pit, or increase the number of pits, or increase both of these. This is illustrated in the example below:

(a) Design for 2 pits with a 10 foot diameter: x = depth of each pit.

$$2\ [3.14(10)(x)=570] \text{ square feet}$$
$$x = 9.1 \text{ feet deep}$$

Use 2 pits 10 feet in diameter and 9.1 feet deep.

(b) Design for 2 pits with a 5-foot diameter: x = depth of each pit.

$$2\ [3.14(5)(x)=570] \text{ square feet}$$
$$x = 18 \text{ feet (approximately)}$$

Use 2 pits 5 feet in diameter and 18 feet deep.

Experience has shown that seepage pits should be separated by a distance equal to 3 times the diameter of the largest pit. For pits over 20 feet in depth, the minimum space between pits should be 20 feet (See figure 11). The area of the lot on which the house is to be built should be large enough to maintain this distance between the pits while still allowing room for additional pits if the first ones should fail. If this can be done, such a leaching system may be approved; if not, other suitable sewerage facilities should be required.

Construction Consideration. -- Seepage pits are usually circular in plan. As shown in Figure 12, the vertical walls are usually lined with masonry placed without mortar below the inlet. The section of the seepage pit above the inlet pipe should be laid with mortared joints or otherwise strengthened.

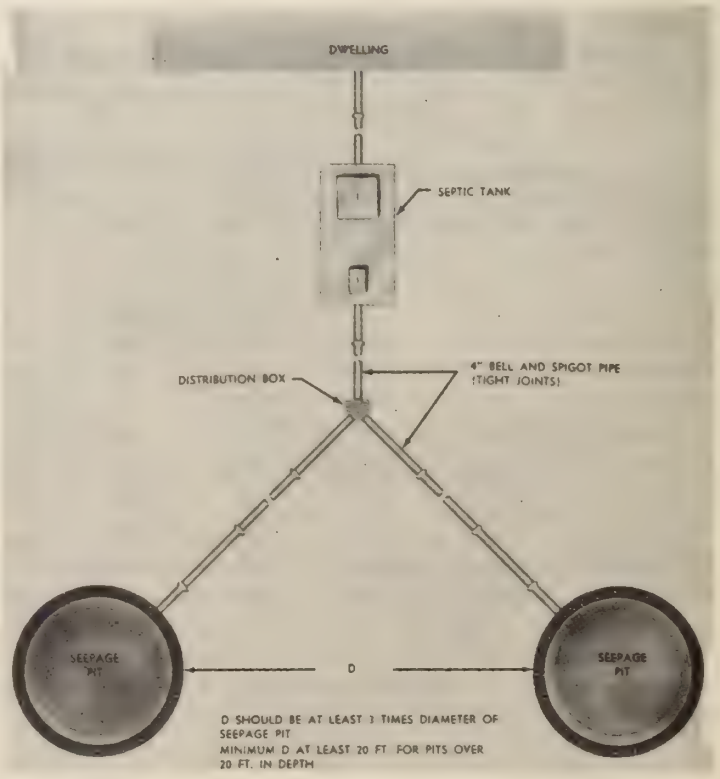

DWELLING
SEPTIC TANK
DISTRIBUTION BOX
4" BELL AND SPIGOT PIPE (TIGHT JOINTS)
SEEPAGE PIT
D
SEEPAGE PIT
D SHOULD BE AT LEAST 3 TIMES DIAMETER OF SEEPAGE PIT
MINIMUM D AT LEAST 20 FT. FOR PITS OVER 20 FT. IN DEPTH

Figure 11.—Disposal system using two seepage pits.

Hard-burned brick, heavyweight concrete block, structural clay tile, and fieldstone are acceptable, if properly laid to provide necessary structural strength. If cored units be used, the cores should be laid in the vertical plane. Whatever the material, the walls should be laid close with no conscious attempt to provide openings between the units. The unevenness of the edges will provide all of the space necessary for the sewage to seep into the surrounding soil. Large openings invite trouble; they make the walls less stable structurally, and permit easier infiltration of the surrounding soil. Pits with large wall openings may be more likely to cave in or collapse than pits with closely built walls. The annular opening between the seepage-pit lining and the surrounding earth should be filled with coarse gravel.

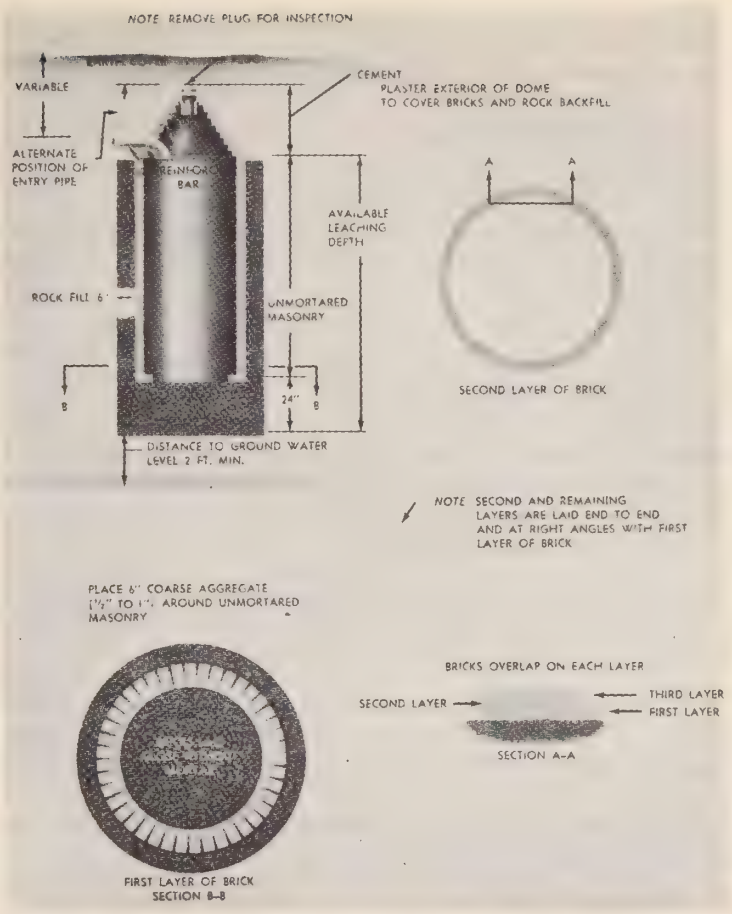

NOTE REMOVE PLUG FOR INSPECTION
VARIABLE
CEMENT PLASTER EXTERIOR OF DOME TO COVER BRICKS AND ROCK BACKFILL
ALTERNATE POSITION OF ENTRY PIPE
REINFORCING BAR
AVAILABLE LEACHING DEPTH
ROCK FILL 6"
UNMORTARED MASONRY
24"
DISTANCE TO GROUND WATER LEVEL 2 FT. MIN.
A A
SECOND LAYER OF BRICK
NOTE SECOND AND REMAINING LAYERS ARE LAID END TO END AND AT RIGHT ANGLES WITH FIRST LAYER OF BRICK
PLACE 6" COARSE AGGREGATE [½" TO 1½" AROUND UNMORTARED MASONRY
BRICKS OVERLAP ON EACH LAYER
SECOND LAYER
THIRD LAYER
FIRST LAYER
SECTION A-A
FIRST LAYER OF BRICK
SECTION B-B

Figure 12.--Seepage pit.

In the construction of a seepage pit, it is particularly important that proper precautions be taken to prevent the side walls from collapsing while workmen are in the hole. Fatal accidents have occurred when this basic safety measure has not been observed. A common method of affording proper protection to the workmen is through the use of sheeting formed by semicircular sections of corrugated metal, braced with semi-circular compression rods which are bolted on the inside with expansion bolts. In another type of seepage-pit construction, the walls are made of precast reinforced concrete sections with slotted holes. For deep seepage pits, or where there is any danger of caving, the sections are installed as the excavation progresses, and are used as the necessary protective sheeting.

Inspection before backfilling of new seepage pit installation is as important as in absorption-field construction.

Abandoned seepage pits should be filled with earth or rock.

Selection of a Septic Tank

Assuming that the lot will be large enough to accommodate one of the types of leaching systems, and that construction of the system be permitted by local authority, the next step will be selection of a suitable septic tank.

Functions of Septic Tanks

Untreated liquid household wastes (sewage) will quickly clog all but the most porous gravel formations. The tank conditions sewage so that it may be more readily percolated into the subsoil of the ground. Thus, the most important function of a septic tank is to provide protection for the absorption ability of the subsoil. Three functions take place within the tank to provide this protection.

1. Removal of Solids. -- Clogging of soil with tank effluent varies directly with the amount of suspended solids in the liquid. As sewage from a building sewer enters a septic tank, its rate

of flow is reduced so that larger solids sink to the bottom or rise to the surface. These solids are retained in the tank, and the clarified effluent is discharged.

2. Biological Treatment. -- Solids and liquid in the tank are subjected to decomposition by bacterial and natural processes. Bacteria present are of a variety called anaerobic which thrive in the absence of free oxygen. This decomposition or treatment of sewage under anaerobic conditions is termed "septic," hence the name of the tank. Sewage which has been subjected to such treatment causes less clogging than untreated sewage containing the same amount of suspended solids.

3. Sludge and Scum Storage. -- Sludge is an accumulation of solids at the bottom of the tank, while scum is a partially submerged mat of floating solids that may form at the surface of the fluid in the tank. Sludge, and scum to a lesser degree, will be digested and compacted into a smaller volume. However, no matter how efficient the process is, a residual of inert solid material will remain. Space must be provided in the tank to store this residue during the interval between cleanings; otherwise, sludge and scum will eventually be scoured from the tank and may clog the disposal field.

If adequately designed, constructed, maintained, and operated, septic tanks are very effective in accomplishing their purpose.

The relative position of a septic tank in a typical subsurface disposal system is illustrated in Figure 11. The liquid contents of the house sewer (A) are discharged first into the septic tank (B), thence to the distribution box (C), and finally into the subsurface absorption field (D).

The heavier sewage solids settle to the bottom of the tank, forming a blanket of sludge. The lighter solids, including fats and greases, rise to the surface and form a layer of scum. A considerable portion of the sludge and scum are liquefied through decomposition or digestion. During this process, gas is liberated from the sludge, carrying a portion of the solids to the surface, where they accumulate with the scum. Ordinarily, they undergo further digestion in the scum layer, and a portion settles again to the sludge blanket on the bottom. This action is retarded if there be much grease in the scum layer. The settling is also retarded because of gasification in the sludge blanket. Furthermore, there are relatively wider fluctuations of flow

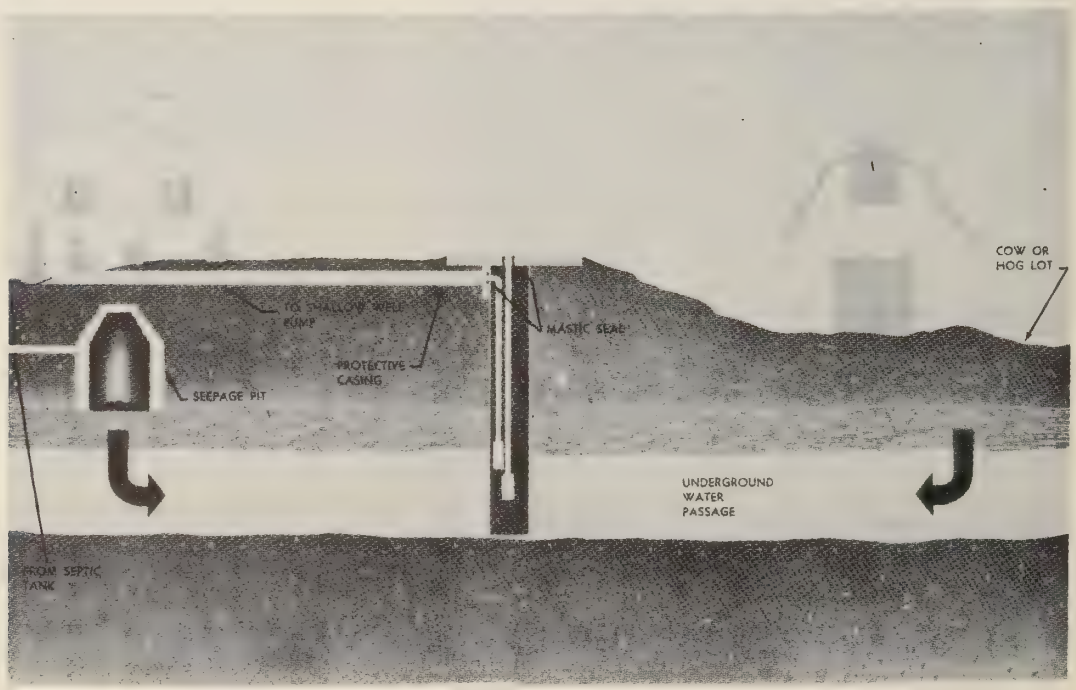


Figure 13. --Pollution of well from sources with lower surface elevations.

in small tanks than in the large units. This effect has been recognized in Table 6 which shows the recommended minimum liquid capacities of household septic tanks.

Location. -- Septic tanks should be located where they cannot cause contamination of any well, spring, or other source of water supply. Underground contamination may travel in any direction and for considerable distances, unless filtered effectively. Underground pollution usually moves in the same general direction as the normal movement of the ground water in the locality. Ground water moves in the direction of the slope or gradient of the water table, i.e., from the area of higher water table to areas of lower water table. In general, the watertable follows the general contour of the ground surface. For this reason, septic tanks should be located downhill from wells or springs. Sewage from disposal systems occasionally contaminate wells having higher surface elevations. Obviously, the elevations of disposal systems are almost always higher than the level of water in such wells as may be located nearby; hence, pollution from a disposal system on a lower surface elevation may still travel downward to the water-bearing stratum as shown in Figure 13. It is necessary, therefore, to rely upon horizontal as well as vertical distances for protection. Tanks should never be closer than 50 feet from any source of water supply; and greater distances are preferred where possible.

Figure 14. --Typical septic-tank shapes.

The septic tank should not be located within 5 feet of any building. The tank should not be located in swampy areas, nor in areas subject to flooding. In general, the tank should be located where the largest possible area will be available for the disposal field. Consideration should also be given to the location from the standpoint of cleaning and maintenance. Where public sewers may be installed at a future date, provision should be made in the household plumbing system for connection to such sewer.

Contrary to popular belief, septic tanks do not accomplish a high degree of bacteria removal. Although the sewage undergoes treatment in passing through the tank, this does not mean that infectious agents will be removed; hence, septic tank effluents cannot be considered safe. The liquid that is discharged from a tank is, in some respects, more objectionable than that which goes in; it is septic and malodorous. This, however, does not detract from the value of the tank. As previously explained, its primary purpose is to condition the sewage so that it will cause less clogging of the disposal field.

Further treatment of the effluent, including the removal of pathogens, is effected by percolation through the soil. Disease-producing bacteria will, in time, die out in the unfavorable environment afforded by soil. In addition, bacteria are also removed by certain physical forces during filtration. This combination of factors results in the eventual purification of the sewage effluent.

Table 6 -- Liquid capacity of tank (gallons)
(Provides for use of garbage-grinders, automatic washers, and other household appliances)

Number of bedrooms	Recommended minimum tank capacity	Equivalent capacity per bedroom
2 or less	750	375
3	900	300
4*	1,000	250

* For each additional bedroom, add 250 gallons.

Capacity. -- Capacity is one of the most important considerations in septic-tank design. Studies have proved that liberal tank capacity is not only important from a functional standpoint, but is also good economy. The liquid capacities recommended in Table 6 allow for the use of all household appliances, including garbage-grinders.

Specifications for Septic Tanks

General. -- Septic tanks should be watertight and constructed of materials not subject to excessive corrosion or decay, such as concrete, coated metal, vitrified clay, heavyweight concrete blocks , or hard-burned bricks. Properly cured precast and cast-in-place reinforced concrete tanks are believed to be acceptable everywhere. Steel tanks meeting Commercial Standard 177-51 of the U. S. Department of Commerce are generally acceptable. Special attention should be given to job-built tanks to insure water tightness. Heavyweight concrete block should be laid on a solid foundation and mortar joints should be well filled. The interior of the tank should be surfaced with two 1/4-inch-thick coats of portland cement-sand plaster. Some typical septic tanks are illustrated in figure 14. Suggested specifications for watertight concrete are as follows:

Not more than 6 gallons of total water should be used for each bag of cement. Since sand usually holds a considerable amount of water, not more than 5 gallons of water per bag of cement should be added at the mixer when sand is of average dampness. More mixing water weakens the concrete and makes it less watertight. For average aggregates, the mix proportions shown in Table 7 will give watertight concrete.

Table 7 -- Average proportions for watertight concrete

Maximum Size Gravel (inches)	Cement (volume)	Water (volume)	Sand (volume)	Gravel (volume)
1-1/2	1	3/4	2-1/4	3
3/4	1	3/4	2-1/2	2-1/2

Precast tanks should have a minimum wall thickness of 2-1/2 inches, and should be adequately reinforced to facilitate handling. When precast slabs are used as covers, they should have a thickness of at least 3 inches and be adequately reinforced.

Table 8 Required Capacities, Dimensions, and Concrete Mix for Septic Tanks Recommended by Louisiana State Department of Health

Number of Persons	Tank Cap. Gals.	Dimensions			Concrete thickness				Approximate Mat. Required		
					Cover slab						
		W	L	D	No. of slabs	T	Walls	Bottom	Sacks Cement	cu. yds. sand	cu. yds. gravel
Up to 9	500	2'9"	6'1"	5'10"	7 @ 12"	3"	6"	6"	16	1 1/2	2 1/2
10 " 14	630	3'0"	7'0"	"	8 @ 12"	4"	6"	"	17	1 3/4	2 1/2
15 " 20	840	3'6"	8'0"	"	9 @ 12"	4"	6"	"	20	2	3
21 " 25	960	4'0"	8'0"	"	solid	4"	6"	"	21	2	3 1/4
26 " 30	1200	4'6"	9'0"	"	"	5"	7"	"	29	2 3/4	4 1/2
31 " 35	1400	4'6"	9'3"	5'6"	"	5"	8"	"	34	3 1/4	5
36 " 40	1600	4'6"	10'0"	5'9"	"	5"	8"	"	37	3 1/2	5 3/4
41 " 45	1780	5'0"	10'0"	5'9"	"	5"	9"	"	43	4 1/4	6 1/2
45 " 50	2000	5'0"	10'8"	6'0"	"	5"	9"	"	46	4 1/2	7

Backfill around septic tanks should be made in thin layers thoroughly tamped in a manner that will not produce undue strain on the tank. Settlement of backfill may be done with the use of water, provided the material is thoroughly wetted from the bottom upwards and the tank is first filled with water to prevent floating.

Adequate access must be provided to each compartment of the tank for inspection and cleaning. Where the top of the tank is located more than 18 inches below the finished grade, manholes and inspection holes should extend to approximately 8 inches below the finished grade (see Fig. 15). In most instances, the extension can be made using clay or concrete pipe, but proper attention must be given to the accident hazard involved when manholes are extended close to the ground surface. A typical single-compartment concrete tank is illustrated in Figure 15.

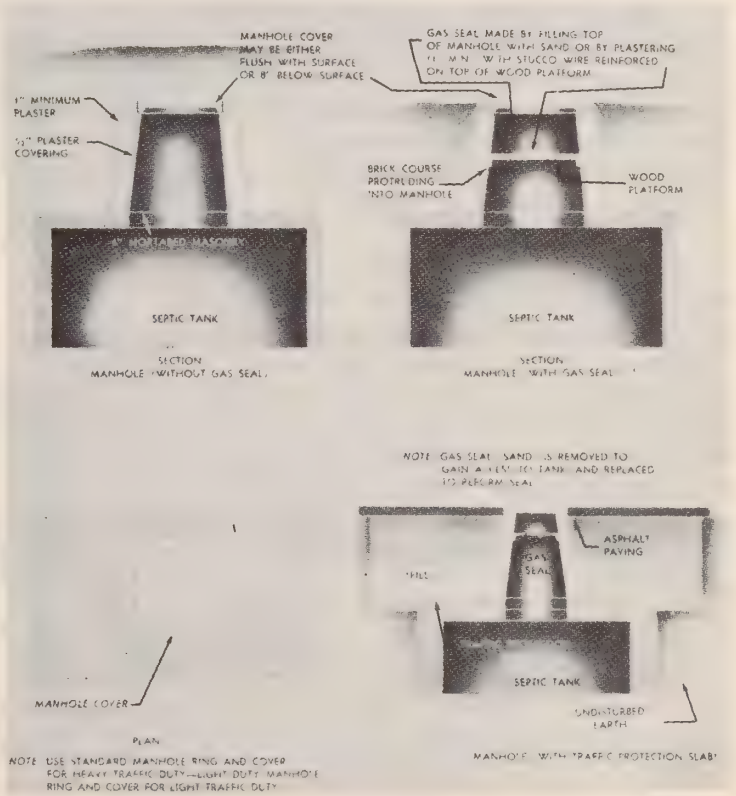

MANHOLE COVER MAY BE EITHER FLUSH WITH SURFACE OR 8" BELOW SURFACE
1" MINIMUM PLASTER
½" PLASTER COVERING
4" MORTARED MASONRY
SEPTIC TANK
SECTION MANHOLE WITHOUT GAS SEAL
GAS SEAL MADE BY FILLING TOP OF MANHOLE WITH SAND OR BY PLASTERING
WITH STUCCO WIRE REINFORCED ON TOP OF WOOD PLATFORM
BRICK COURSE PROTRUDING INTO MANHOLE
WOOD PLATFORM
SEPTIC TANK
SECTION MANHOLE WITH GAS SEAL
NOTE GAS SEAL SAND IS REMOVED TO GAIN ACCESS TO TANK AND REPLACED TO RECLAIM SEAL
ASPHALT PAVING
GAS SEAL
FILL
SEPTIC TANK
UNDISTURBED EARTH
MANHOLE COVER
PLAN
MANHOLE WITH TRAFFIC PROTECTION SLAB
NOTE USE STANDARD MANHOLE RING AND COVER FOR HEAVY TRAFFIC DUTY—LIGHT DUTY MANHOLE RING AND COVER FOR LIGHT TRAFFIC DUTY

Figure 15. --Design of manholes.

Outlet. -- It is important that the outlet device penetrate just far enough below the liquid level of the septic tank to provide a balance between sludge and scum accumulation; otherwise, part of the advantage of capacity is lost. A vertical section of a properly operating tank would show it divided into three distinct layers; scum at the top, a middle zone free of solids (called "clear space"), and a bottom layer of sludge. The outlet device retains scum in the tank, but at the same time, it limits the amount of sludge that can be accommodated without scouring, which results in sludge discharging in the effluent from the tank. Observations of sludge accumulations in the field, indicate that the outlet device should generally extend to a distance below the surface equal to 40 percent of the liquid depth. For horizontal, cylindrical tanks, this should be reduced to 35 per cent. For example, in a horizontal cylindrical tank having a liquid depth of 42 inches, the outlet device should penetrate 42 x .35 = 14.7 inches below the liquid level.

The outlet device should extend above the liquid line to approximately 1 inch from the top of the tank. The space between the top of the tank and the baffle allows gas to pass off through the tank into the house vent.

Inlet. -- The inlet invert should enter the tank at least 1 inch (preferably 3 inches) above the liquid level in the tank. This free drop prevents backwater and stranding of solid material in the house sewer leading to the tank.

A vented inlet tee or baffle should be provided to divert the incoming sewage downward. It should penetrate at least 6 inches below the liquid level, but in no case should the penetration be greater than that allowed for the outlet device. A number of arrangements commonly used for inlet and outlet devices are shown in Figure 17.

Tank Proportions. -- The available data indicate that, for tanks of a given capacity and surfaced area, shallower tanks function as well as deep ones. Also, for tanks of a given capacity and depth, the shape of a septic tank is unimportant. However, it is recommended that the smallest plan dimension be at least 2 feet. Liquid depth may range between 30 and 60 inches.

Storage Above Liquid Level. -- Capacity is required above the liquid line to provide for that portion of the scum which floats above the liquid. Although some variation is to be expected, on the average about 30 percent of the total scum will accumulate above the liquid line. In addition to the provision for scum storage, 1 inch is usually provided at the top of the tank to permit free passage of gas back to the inlet and house vent pipe.

For tanks having straight, vertical sides, the distances between the top of the tank and the liquid line should be equal to approximately 20 percent of the liquid depth. In horizontal, cylindrical tanks, area equal to approximately 15 percent of the total circle should be provided above the liquid

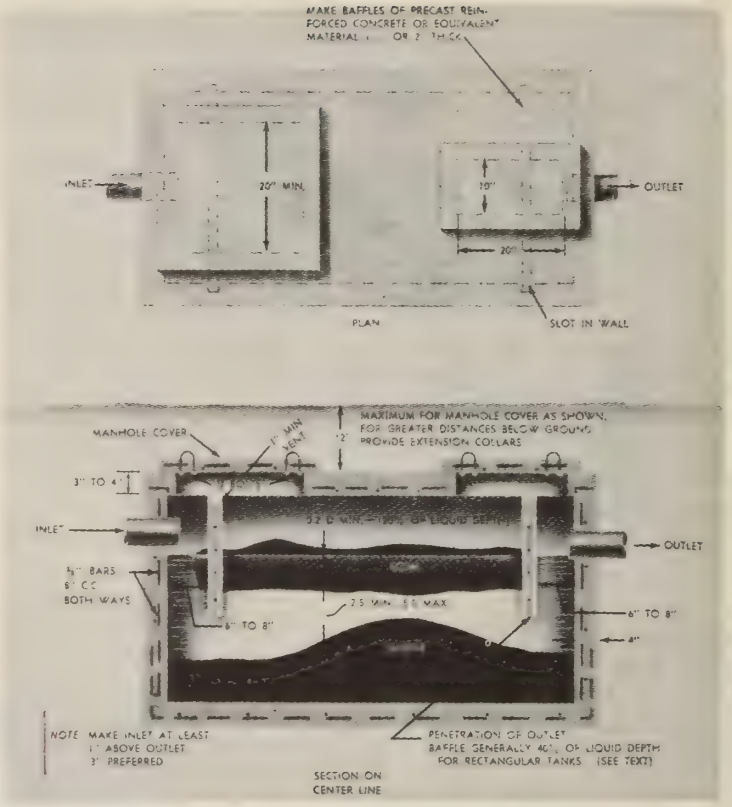

MAKE BAFFLES OF PRECAST REINFORCED CONCRETE OR EQUIVALENT MATERIAL
INLET
20" MIN.
OUTLET
PLAN
SLOT IN WALL
MANHOLE COVER
MAXIMUM FOR MANHOLE COVER AS SHOWN. FOR GREATER DISTANCES BELOW GROUND, PROVIDE EXTENSION COLLARS
3" TO 4"
INLET
OUTLET
6" TO 8"
NOTE MAKE INLET AT LEAST 1" ABOVE OUTLET 3" PREFERRED
PENETRATION OF OUTLET BAFFLE GENERALLY 40% OF LIQUID DEPTH FOR RECTANGULAR TANKS (SEE TEXT)
SECTION ON CENTER LINE

Figure 16. --Household septic tank.

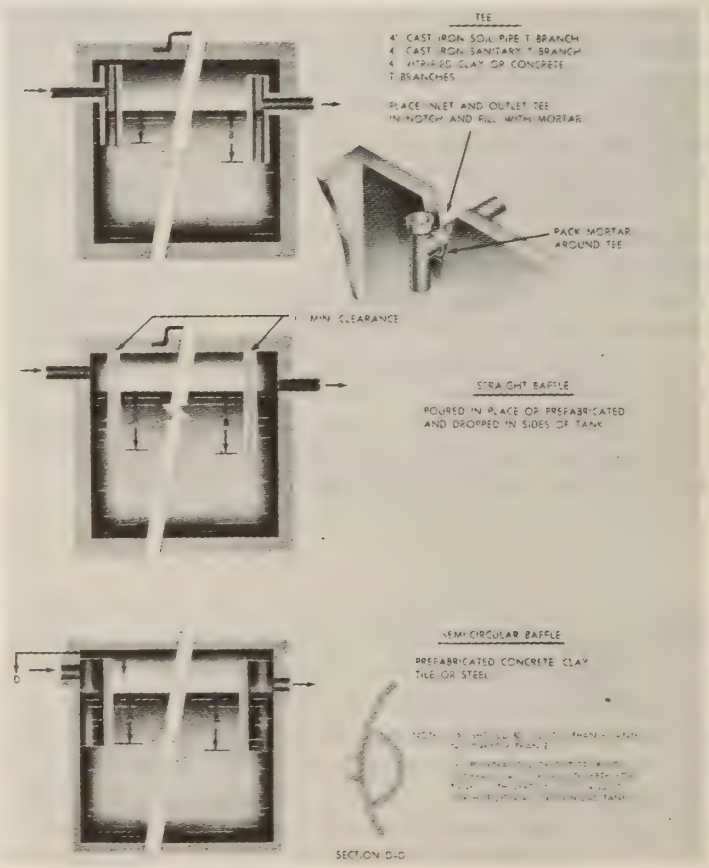


Figure 17 --Types of inlet and outlet devices.

level. This condition is met if the liquid depth (distance from outlet invert to bottom of tank) is equal to 79 percent of the diameter of the tank.

Use of Compartments.--Although a number of arrangements are possible, the term "compartmentation," as used here, refers to a number of units placed in series. These can be either separate units linked together, or sections enclosed in one continuous shell (as in Figure 18) with watertight partitions separating the individual compartments.

A single-compartment tank will give acceptable performance. The available research data indicate, however, that a two-compartment tank, with the first compartment equal to one-half to two-thirds of the total volume, provides an extra degree of suspended solids removal, which may be especially valuable under tight-soil conditions. Tanks with three or more equal compartments give at least as good performance as single-compartment tanks of the same total capacity. No tank should have an excess of four compartments, and each compartment shall have a minimum plan dimension of 2 feet with a liquid depth ranging from 30 to 60 inches.

An access manhold should be provided to each compartment. Venting between compartments should be provided to allow free passage of gas. Inlet and outlet fittings in the compartmented tank should be proportioned as for a single tank. (See Figure 17.) The same allowance should be made for storage above the liquid line as in a single tank.

General Information on Septic Tanks

Cleaning. -- Septic tanks should be cleaned before too much sludge or scum is allowed to accumulate. If either the sludge or scum approaches too closely to the bottom of the outlet device, particles will be scoured into the disposal field

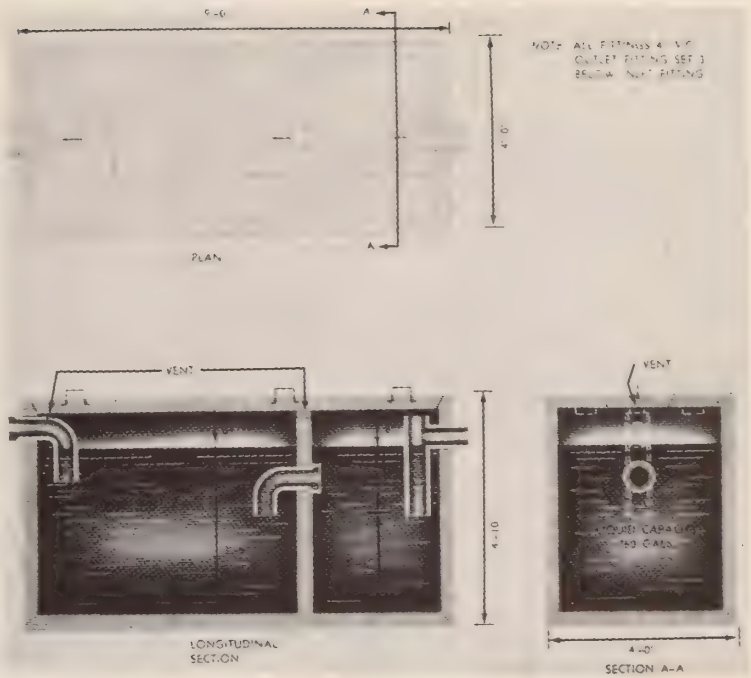


Figure 18. --Precast septic tank.

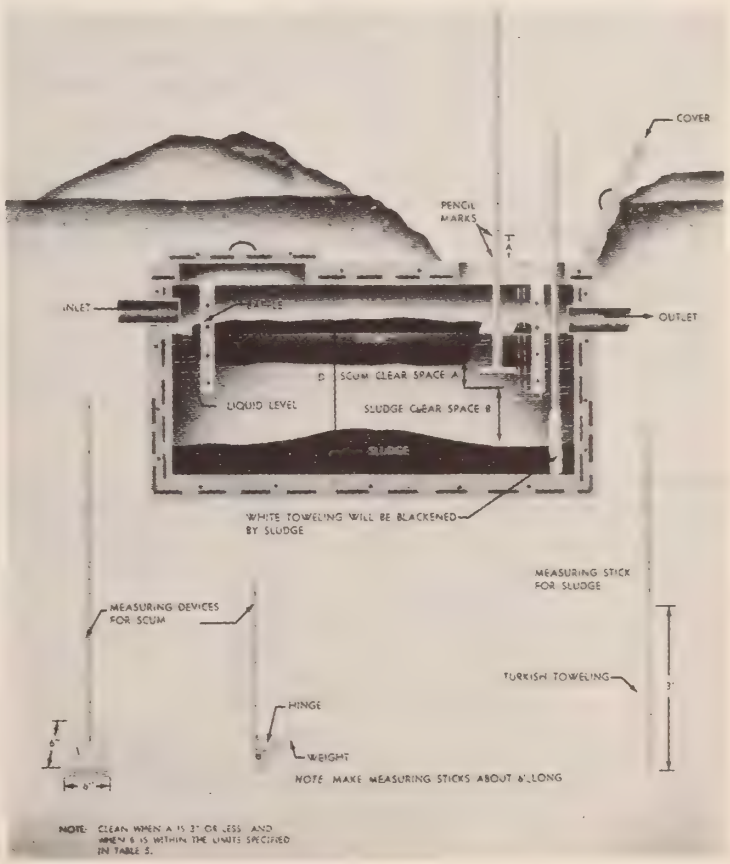
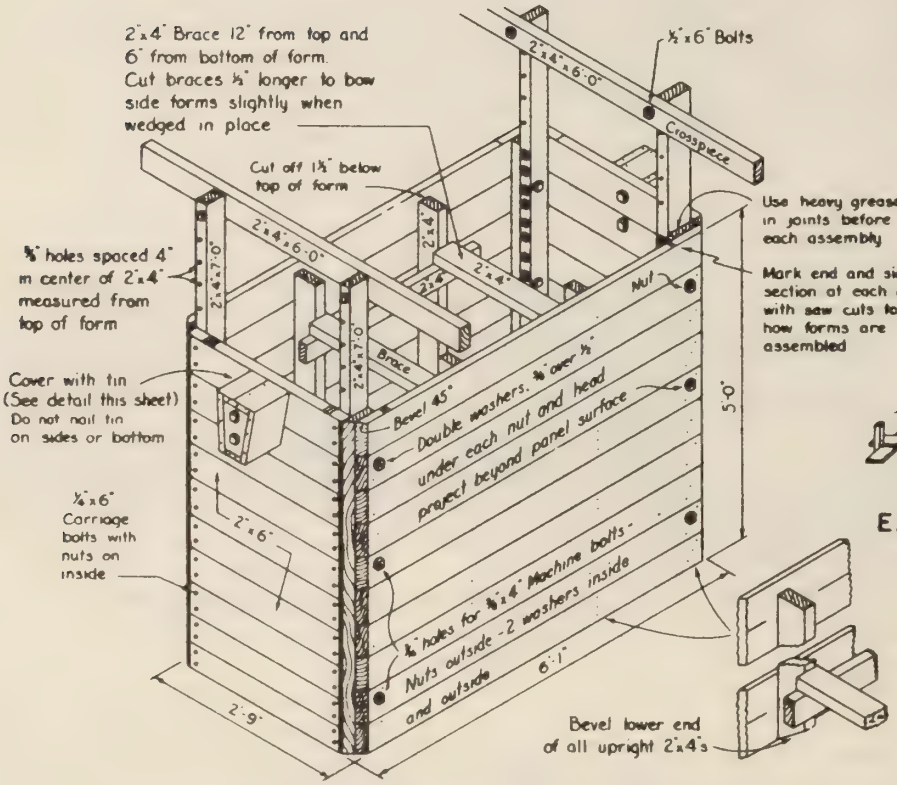
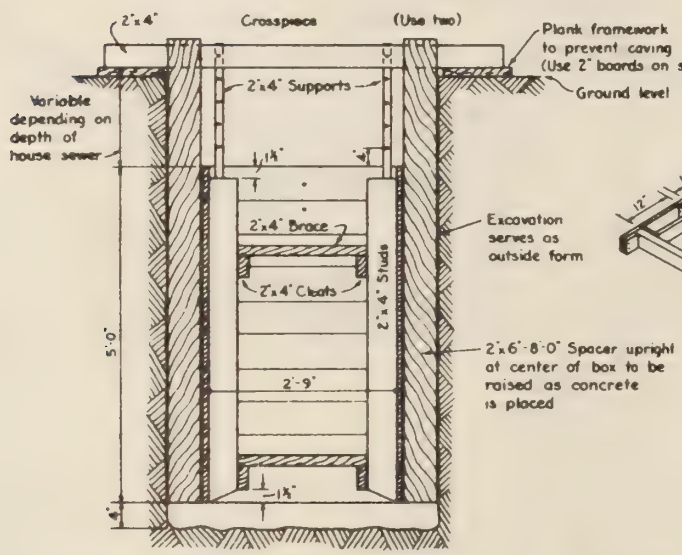
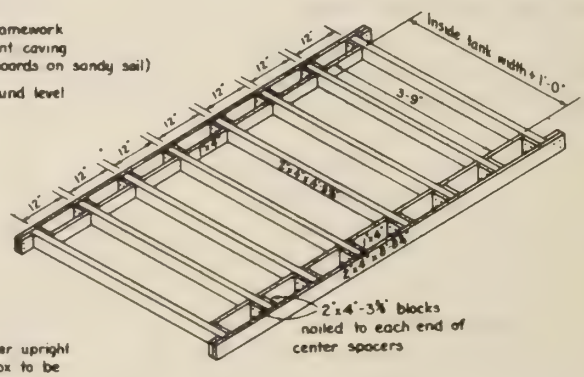


Figure 19.--Devices for measuring sludge and scum.

Fig. 20 Re-usable Forms for Septic Tank Construction


2"x4" Brace 12" from top and 6" from bottom of form. Cut braces ½" longer to bow side forms slightly when wedged in place
½"x6" Bolts
2"x4"x6'-0"
Crosspiece
Cut off 1½" below top of form
Use heavy grease in joints before each assembly
Mark end and side section at each corner with saw cuts to show how forms are assembled
⅝" holes spaced 4" in center of 2"x4" measured from top of form
Nut
Cover with tin (See detail this sheet) Do not nail tin on sides or bottom
Bevel 45°
Double washers, ⅝" over ½" under each nut and head project beyond panel surface
5'-0"
¼"x6" Carriage bolts with nuts on inside
2"x6"
¾" holes for ⅝"x4" Machine bolts - Nuts outside - 2 washers inside and outside
6'-1"
2'-9"
Bevel lower end of all upright 2"x4"s
GENERAL VIEW OF RE-USABLE INSIDE FORMS FOR 500 GALLON TANK
39"
71½"
EXCAVATION FRAME
500 GALLON TANK





and will clog the system. Eventually, when this happens, liquid may break through to the ground surface, and the sewage may back up in the plumbing fixtures. When a disposal field is clogged in this manner, it is not only necessary to clean the tank, but it also may be necessary to construct a new disposal field.

The tank capacities given in Table 9 will give a reasonable period of good operation before cleaning becomes necessary. There are wide differences in the rate that sludge and scum will accumulate from one tank to the next. For example, in one case out of 20, the tank will reach the danger point, and should be cleaned, in less than 3 years. Tanks should be inspected at least once a year and cleaned when necessary.

Although it is difficult for most homeowners, actual inspection of sludge and scum accumulations is the only way to determine definitely when a given tank needs to be pumped. When a tank is inspected, the depth of sludge and scum should be measured in the vicinity of the outlet baffle. The tank should be cleaned if either: (a) The bottom of the scum mat be within approximately 3 inches of the bottom of the outlet device; or (b) sludge comes within the limits specified in Table 9 (see figure 19).

Table 9 Allowable sludge accumulation

Liquid capacity of tank, gallons	Liquid depth		
	3 feet	4 feet	5 feet
	Distance from bottom of outlet device to top of sludge, inches		
500	11	16	21
600	8	13	18
750	6	10	13
900	4	7	10
1,000	4	6	8

Scum can be measured with a stick to which a weighted flap has been hinged, or with any device that can be used to feel out the bottom of the scum mat. The stick is forced through the mat, the hinged flap falls into a horizontal position, and the stick is raised until resistance from the bottom of the scum is felt. With the same tool, the distance to the bottom of the outlet device can be found (see figure 19).

A long stick wrapped with rough, white toweling and lowered to the bottom of the tank will show the depth of sludge and the liquid depth of the tank. The stick should be lowered behind the outlet device to avoid scum particles. After several minutes, if the stick be carefully removed, the sludge line can be distinguished by sludge particles clinging to the toweling.

In most communities where septic tanks are used, there are firms which conduct a business of cleaning septic tanks. The local health department can make suggestions on how to obtain this service. Cleaning is usually accomplished by pumping the content of the tank into a tank truck. Tanks should not be washed or disinfected after pumping. A small residual of sludge should be left in the tank for seeding purposes. The material removed may be buried in uninhabited places or, with permission of the proper authority, emptied into a sanitary sewer system. It should never be emptied into storm drains or discharged directly into any stream or watercourse. Methods of disposal should be approved by the health authorities.

When a large septic tank is being cleaned, care should be taken not to enter the tank until it has been thoroughly ventilated and gases have been removed to prevent explosion hazards or asphyxiation of the workers. Anyone entering the tank should have one end of a stout rope tied around his waist, with the other end held above ground by another person strong enough to pull him out if he should be overcome by any gas remaining in the tank.

Grease Interceptors. -- Grease interceptors (grease traps) are not ordinarily considered necessary on household sewage disposal systems. The discharge from a garbage-grinder should never be passed through them. The septic-tank capacities recommended in this chapter are sufficient to receive the grease normally discharged from a home.

Chemicals. -- The functional operation of septic tanks is not improved by the addition of disinfectants or other chemicals. In general, the addition of chemicals to a septic tank is not recommended. Some proprietary products which are claimed to "clean" septic tanks contain sodium hydroxide or potassium hydroxide as the active agent. Such compounds may result in sludge bulking and a large increase in alkalinity, and may interfere with digestion. The resulting effluent may severely damage soil structure and cause accelerated clogging, even though some temporary relief may be experienced immediately after application of the product.

Frequently, however, the harmful effects of ordinary household chemicals are overemphasized. Small amounts of chlorine bleaches, added ahead of the tank, may be used for odor control and will have no adverse effects. Small quantities of lye or caustics normally used in the home, added to plumbing fixtures is not objectionable as far as operation of the tank is concerned. If the septic tanks be as large as herein recommended, dilution of the lye or caustics in the tank will be enough to overcome any harmful effects that might otherwise occur.

Some 1,200 products, many containing enzymes, have been placed on the market for use in septic tanks, and extravagant claims have been made for some of them. As far as is known, however, none has been proved of advantage in properly controlled tests.

Soaps, detergents, bleaches, drain cleaners, or other material, as normally used in the household, will have no appreciable adverse effect on the system. However, as both the soil and essential organisms might be susceptible to large doses of chemicals and disinfectants, moderation should be the rule. Advice of responsible officials should be sought before chemicals arising from a hobby or home industry are discharged into the systems.

Miscellaneous. -- It is generally advisable to have all sanitary wastes from a household discharge to a single septic tank and disposal system. For household installations, it is usually more economical to provide a single disposal system than two or more with the same total capacity. Normal household waste including that from the laundry, bath, and kitchen, should pass into a single system.

Roof drains, foundation drains and drainage from other sources producing large intermittent or constant volumes of clean water should not be piped into the septic tank or absorption area. Such large volumes of water will stir up the contents of the tank and carry some of the solids into the outlet line; the disposal system following the tank will likewise become flooded or clogged, and may fail. Drainage from garage floors or other sources of oily waste should also be excluded from the tank.

Toilet-paper substitutes should not be flushed into a septic tank. Paper towels, newspaper, wrapping paper, rags, and sticks may not decompose in the tank, and are likely to lead to clogging of the plumbing and disposal system.

Waste brines from household water-softener units have no adverse effect on the action of the septic tank, but may cause a slight shortening of the life of a disposal field installed in a structured clay-type soil.

Adequate venting is obtained through the building plumbing if the tank and the plumbing be designed and installed properly. A separate vent on a septic tank is not necessary.

A chart showing the location of the septic tank and disposal system should be placed at a suitable location in dwellings served by such a system. Whether furnished by the builder, septic tank installer, or the local health department, the charts should contain brief instructions as to the inspection and maintenance required. The charts should assist in acquainting homeowners of the necessary maintenance which septic tanks require, thus forestalling failures by assuring satisfactory operation. The extension of the manholes or inspection holes of the septic

tank to within 8 inches of the ground surface will simplify maintenance and cleaning.

Abandoned septic tanks should be filled with earth or rock.

Cesspool. -- A cesspool is a covered pit with open-jointed lining into which raw sewage is discharged, the liquid portion of which is disposed of by seepage or leaching into the surrounding porous soil, the solids or sludge being retained in the pit. A cesspool is not recommended as a substitute for a septic tank since the raw sewage discharged into the cesspool tends to seal the openings in the lining and the surrounding porous formation, thereby reducing the leaching area and often causing the cesspool to overflow. Such conditions are dangerous because the pollution enters the soil at a depth below the upper layers of the soil where are found the aerobic nitrifying bacteria which carry on the work of purification of waste organic matter. Thus the sewage, instead of being oxidized or purified, seeps into the soil and gradually extends the zone of pollution, and may endanger the safety of wells a considerable distance away. The second danger is that disease germs may be discharged onto the surface of the ground or into shallow ditches. Since the effluent of the tank is putrescible, it frequently causes a nuisance by collecting in stagnant pools and giving rise to very objectionable odors. For small families in localities where the soil is sufficiently porous, these unsanitary and dangerous cesspools may be remodeled by making them water-tight and by allowing the overflow to filter through the soil by means of various filtering devices.

Cesspools present definite health hazards when excavated to excessive depth into waterbearing formations, or where the ground-water table is close to the surface, or where the overflow pollutes the surface. Their use may be permitted with caution only where septic tanks are impractical and the possibility of contaminating any ground-water supply is extremely remoted. Many States have regulations prohibiting the installation of cesspools.

Cesspools should be located at least 150 feet from wells, 100 feet from seepage pits, and 20 ft. from dwelling foundations. They should never be used in the vicinity of shallow wells, and in any case only where approved by the health department.

In the construction of a cesspool, a hole 3 ft. or more in diameter and of sufficient depth to encounter a porous formation should be provided. Open-joint curbing should be used in a similar manner as that for curbing of seepage pits, and a slab cover with a manhole opening should be provided to permit access. All cesspools should be constructed with an overflow to a properly designed and constructed seepage pit. The overflow pipe to the seepage pit should be at least 6 inches lower than the elevation of the inlet.

Abandoned wells, drill holes, or abandoned mines should never be used either as cesspools or seepage pits for sewage disposal. Such holes should be filled or plugged in order to prevent both the contamination of ground waters and accidents.

Abandoned septic tanks should be filled with earth or rock.

Septic-Tank Systems for Institutions, Recreational Areas and Other Establishments

The soundest advice available to anyone contemplating such a system is the early retention of competent sanitary-engineering consultation, whose first determination should be the suitability of this method of sewage disposal for the proposed establishment.

Any institutional septic-tank system must incorporate appurtenances and supplemental features of design to meet the requirements of the establishment and varying site conditions.

Estimates of Sewage Quantities

Where there are water meters in existing buildings, the quantity of sewage may best be estimated from the recorded meter readings.

In using water-meter readings for estimating the quantity of sewage to be contributed, some allowance should also be made for maximum conditions that may not be readily apparent from the readings. For example, water consumption by an ordinary family of four in an apartment building may average 48 gallons of water per person per day over a period of 3 months, but may

actually range to perhaps 60 gallons per person on days when water consumption is heaviest, as on washdays. Besides these peak loads, some allowance should be made for the sewage contributed by occasional guests. Therefore, when computing sewage flows from average meter readings, a minimum factor of safety of about 25 percent should be allowed to cover the range of variations. Accordingly, the design of a disposal system for an apartment house where the average usage is 48 gallons per person per day, should be based upon a computed maximum usage of at least 60 gallons per person per day.

Conversely, unusually high meter readings may be caused by lawn sprinkling or by leakage of water that does not enter the disposal system. Due allowances should be made for abnormalties of this kind.

Where measurements of water consumption are not possible, as where water-meter records are not available, or where disposal facilities are being planned for a new building, it is necessary to use other methods of estimating the amount of sewage to be discharged. One way is to base the computed flow on the number of bedrooms, as in private residences. Another way is to compute the flow on the basis of the number and kinds of plumbing fixtures. If the building be used as a restaurant, the number of patrons or the number of meals served may be the best criterion. The competent designer will base his estimates upon a combination of the various influencing factors. He will consider each case on its own merits, especially when disposal facilities are being designed for a large institution where the cost of construction will amount to a considerable sum. If definite information and accurate water measurements be not available, the quantity of sewage may be estimated from experiences at establishments similar to that for which the new sewage-disposal facilities are intended. Table 10 may be helpful in such cases.

The quantities listed in the table are merely the best averages available at this time, and they should be modified in localities or establishments where experience indicates a need for so doing.

It is sometimes economical and advisable to construct separate disposal systems for different types of wastes at a given establishment. The decision as to the number of disposal systems may be influenced by conditions of terrain, topography, and locations of the buildings contributing to the wastes. At large camps, for example, and at some resorts, kitchens and central dining facilities may be located at appreciable distances from the barracks or cottages and cabins. Under such circumstances, the kitchens may be provided with separate disposal systems, including facilities for the removal of grease ahead of the septic tank.

Table 10. Quantities of sewage flow

Type of establishment	Gallons per person per day
Small dwellings and cottages with seasonal occupancy	50
Single-family dwellings	75
Multiple-family dwellings (apartments)	60
Rooming houses	40
Boarding houses	50
Additional kitchen wastes for nonresident boarders	10
Hotels without private baths	50
Hotels with private baths (2 persons per room)	60
Restaurants (toilet and kitchen wastes per patron)	7 to 10
Restaurants (kitchen wastes per meal served)	2 1/2 to 3
Additional for bars and cocktail lounges	2
Tourist camps or trailer parks with central bathhouse	35
Tourist courts or mobile home parks with individual bath units	50
Resort camps (night and day) with limited plumbing	50
Luxury camps	100 to 150
Work or construction camps (semipermanent)	50
Day camps (no meals served)	15
Day schools without cafeterias, gymnasiums, or showers	15
Day schools with cafeterias, but no gymnasiums or showers	20
Day schools with cafeterias, gyms, and showers	25
Boarding schools	75 to 100
Day workers at schools and officers (per shift)	15
Hospitals	150 to 250
Institutions other than hospitals	75 to 125
Factories (gallons per person per shift, exclusive of industrial wastes)	15 to 35
Picnic parks (toilet wastes only), (gallons per picnicker)	5
Picnic parks with bathhouses, showers, and flush toilets	10
Swimming pools and bathhouses	10
Luxury residences and estates	100 to 150
Country clubs (per resident member)	100
Country clubs (per nonresident member present)	25
Motels (per bed space)	40
Motels with bath, toilet, and kitchen wastes	50
Drive-in theaters (per car space)	5
Movie theaters (per auditorium seat)	5
Airports (per passenger)	3 to 5
Self-service laundries (gallons per wash, i.e., per customer)	50
Stores (per toilet room)	400
Service stations (per vehicle served)	10

Example: In a household contributing 75 gallons of sewage per day per person, as shown in column 4, an average breakdown for each of the four types of wastes listed might be about 10 gallons per day per person for kitchen wastes; 25 gallons per day per person for toilet wastes; 25 gallons per day per person for shower wastes, bathtubs, and washbasins; and about 15 gallons per day per person for laundry wastes.

Table 11 Estimated distribution of sewage flows, in gallons per day per person

Type of waste	Volume, gallons per day per person				
Total Flow (gallons) ----------	30	40	50	75	100
Kitchen wastes ----------	*0	7	10	10	15
Toilet wastes ----------	15	15	20	25	30
Showers, washbasins, etc. ----------	15	18	20	25	35
Laundry wastes ----------	*0	*0	*0	15	20

*No wastes from these uses.

Separate systems may also be used for community bathhouses. When this is done, the total per capita flow must be broken down into its component parts, and some allowance should be made for the amount of sewage tributary to the different disposal systems. Table 11 illustrates how this may be done where there are no definite data as to the exact distribution of flow.

For certain types of new establishments, the designing engineer may be unable to obtain from his clients accurate estimates as to the number of patrons to be served by the disposal facilities. This is particularly true in the case of restaurants and at recreational places, such as picnic areas, country clubs, and the like. In such cases, computations and estimates may best be made from the number of plumbing fixtures installed. Table 12 indicates average values for quantities of sanitary wastes per fixture at country clubs with modern plumbing.

Table 12 -- Sewage flow from country clubs

Type of fixture	Gallons per day per fixture	Type of fixture	Gallons per day per fixture
Showers ----------	500	Toilets ----------	150
Baths ----------	300	Urinals ----------	100
Lavatories --------	100	Sinks ----------	50

Estimates of sewage quantities from golf clubs should be checked and calculations based on the weekend population. Allowances of 10 gallons per person for showers and 7 gallons per person for toilet and kitchen wastes, both for the average weekend population, have been found reasonable.

Table 13 shows one method used in estimating the amount of sewage discharged hourly during the hours when public parks are open. Similar figures may be used for fairgrounds, carnivals, ball parks, etc.

Table 13 Sewage flow at public parks
(During hours when park is open)

Type of fixture	Gallons per hour per fixture	Type of fixture	Gallons per hour per fixture
Flush toilets ---------	36	Showers ----------	150
Urinals ----------	10	Faucets ----------	15

Estimates of Leaching Areas

With information from percolation tests and with due consideration to the results of test borings or subsurface explorations, the rate at which sewage may be applied to a soil-absorption field may be taken from Table 14 or from the corresponding curve in Figure 20.

Table 14 Allowable rate of sewage application to a soil-absorption system

Percolation rate (time in minutes for water to fall 1 inch)	Maximum rate of sewage application (gallons per square foot per day)[1] for standard trenches[2] and seepage pits[3]	Percolation rate (time in minutes for water to fall 1 inch	Maximum rate of sewage application (gallons per square foot per day)[1] for standard trenches[2] and seepage pits[3]
1 or less	5.0	10	1.6
2	3.5	15	1.3
3	2.9	30[4]	0.9
4	2.5	45[4]	0.8
5	2.2	60[4,5]	0.6

1. Not including effluents from septic tanks that receive wastes from garbage-grinders and automatic washing machines.
2. Absorption area for standard trench is figured as trench-bottom area.
3. Absorption area for seepage pits is effective side-wall area.
4. Over 30 unsuitable for seepage pits.
5. Over 60 unsuitable for leaching systems.

Table 14 and the curves in Figure 21 do not allow for wastes from garbage-grinders and automatic washing machines. Discharge from these appliances to an institutional septic-tank system calls for extra capacity of 20 and 40 percent, respectively, over the calculated leaching-area values. If both of these appliances are installed, the leaching area should be increased by about 60 percent over the calculated value. Tables for private residences make allowance for these types of waste in giving specifications for small household systems, but they may never occur in institutional effluents, such as those from factories and offices. Other institutions, such as a country club or drive-in theatre with eating facilities, may contribute wastes from garbage-grinders, but not from automatic washing machines. As previously emphasized, all institutions should have their systems designed by an engineer who is competent to place proper evaluations on the kind of wastes to be contributed.

Use of Table 14 is demonstrated in the following examples, which illustrate the design for the two types of soil absorption systems. For each example assume: 5,000 gallons of sewage per day to be disposed of; percolation rate, 1 inch in 5 minutes.

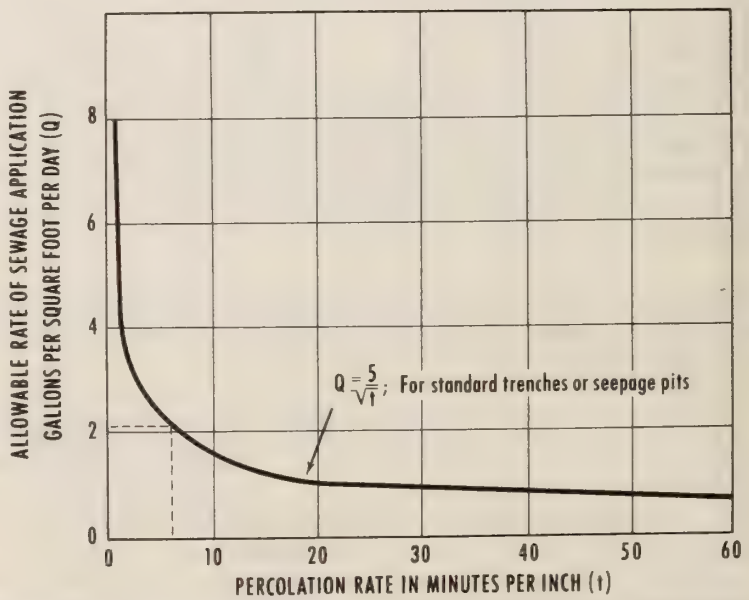


Figure 21. --Graph showing relation between percolation rate and allowable rate of sewage application.

Example 1. --Absorption Trenches

Standard trench, 2 feet width.

5,000 gal./day ÷ 2.2 gal./sq. ft./day = 2,270 square feet of absorption area required.

2,270 ÷ 2 sq. ft./linear ft. = 1,135 feet of trench required.

With garbage-grinder only: 1,135 + (.20x1,135) = 1,362 linear feet.

With automatic washing machine only: 1,135 + (.40x 1,135) = 1,589 linear feet.

With garbage-grinder and automatic washing machine: 1,135 + (.60x1,135) = 1,816 linear feet.

Example 2. -- Seepage Pits:

Seepage Pit, 10-foot diameter; depth of effective absorption area 25 feet; let x = depth of pit in feet; D equal pit diameter in feet. Effective sidewall area equals total area needed.

$\pi D (x) = 2270$ sq. ft.
$3.14 (10) (x) = 2270.$
Solve for x, depth of pit = 72 ft.

Obviously, more than one pit is required.
Design for 3 pits, 10 ft. in diameter.
$72 \div 3 = 24$ ft.
Use 3 pits, 10 ft. in diameter and 24 ft. deep.

With garbage-grinder only : $3.14 (10) (x) = 2270 + 2270 (.20) = 2724$ sq. ft. Solve for x = 86.4 ft. Use 4 pits, 10 ft. in diameter and 21.6 ft. deep.

With automatic washing machine only: $3.14 (10) (x) = 2270 + 2270 (.40) = 3178$ sq. ft. Solve for x = 101 ft. needed. Use 5 pits, 10 ft. in diameter and 20.2 ft. deep.

With garbage-grinder and automatic washing machine: $3.14 (10) (x) = 2270 + 2270 (.60) = 3632$ sq. ft. Solve for x = 115.7 ft. required. Use 5 pits, 10 ft. in diameter and 23.1 ft. deep.

Building Sewers

The building sewer or house sewer is the pipeline carrying sewage from the building or house drain to a private sewer, public sewer, septic tank, or other point of disposal. It usually extends from a point 2 or 3 feet outside the building, where it is connected to the building drain.

The building sewer should be constructed of cast iron, vitrified clay, concrete, bituminized fiber, asbestos cement, or other durable material. All joints in the sewer line should be watertight and rootproof. The grade of the building sewer should be at least 2 percent (2-foot fall per 100 feet, or 1/4-inch per foot) except for the 10 feet immediately preceding the septic tank, where it should not exceed 2 percent. Buildings should be planned so that a proper slope of the building sewer can be obtained. Where the terrain is extremely flat, however, it may be advisable to allow a slope of only 6 inches per 100 feet, or 0.5 percent (see Table 15).

The size of the pipeline to a septic tank is generally dependent upon its ability to allow objects to pass, and upon its capacity to conduct high flows for short periods, rather than upon its capacity in relation to the average flow. No building sewer serving water closets should be less than 4 inches in size. The relationship of minimum sizes to the slopes and to the number of fixtures is indicated in Table 15.

Table 15 Maximum number of fixture units* served by building sewer of indicated size and slope

Minimum pipe diameter, inches	Pipe slope (inch per foot)			
	1/16	1/8	1/4	1/2
4		180	216	250
5		390	480	575
6		700	840	1,000
8	1,400	1,600	1,920	2,300
10	2,500	2,900	3,500	4,200
12	3,900	4,600	5,600	6,700

* A fixture unit is a quantity in terms of which the load-producing effects of different plumbing fixtures on the plumbing system are expressed on some arbitrarily chosen scale. For example, a small lavatory is rated as 1 fixture unit; a kitchen sink, 2; a bathtub, 2; a tank-operated water closet, 4; and a valve-operated water closet, 8. A table of ratings from the American Standard National Plumbing Code is given in Chapter XIII on Plumbing.

Cleanouts should be provided at the junction of the building drain and building sewer and at each change in direction of the building sewer. They should also be provided at intervals of not more than 50 feet on lines of 4-inch diameter, or 100 feet in larger pipes.

That portion of the sewer line within 10 to 50 feet of any well or suction line from a well, or within 10 feet of any drinking-water supply line under pressure, or within 5 feet of any basement foundation, should be made of cast iron with leaded joints. Cast iron should also be required wherever the line crosses under driveways with less than 3 feet of earth cover. While no general statement can be made to cover all cases, it is suggested that no sewer line pass within 25 feet of a well or other source of water supply, and that all sewers within 50 feet of such sources of water supply be of cast-iron pipe with watertight joints. Where sewer lines are in the vicinity of trees or dense shrubs, and are not constructed of cast iron as indicated above, the joint should be made of special, root-resistant construction.

Bends ahead of the septic tank should be limited to 45° or less wherever possible. If 90° bends cannot be avoided, they should be made with two 45° ells, or a lone-sweep quarter curve or bend.

Collection Systems

At institutions where there are a number of buildings, it may be advisable to provide a system of sewers for the collection, transportation, and possibly the pumping of sewage to the septic tank. In general, the collection system should be designed for a capacity expected to be adequate for at least one decade, and preferably two. It is usually advisable to design the sewers with capacities, when running full, of not less than 10 times the average estimated flow of sewage.

Institutional sewers carrying raw or untreated sewage should be at least 6 inches in diameter and have slopes of at least 1/8 inch to the foot (1.0 percent). In very small installations, 4-inch sewers at 1/4 inch per foot (2 percent) may be used to carry raw sewage, and 4-inch sewers with slopes of 1/8 inch per foot are acceptable for carrying settled sewage. All sewers should be designed and constructed with hydraulic slopes sufficient to give mean velocities, when flowing full, of not less than 2.0 feet per second, based on Kutter's or Manning's formula using as "n" value of 0.013. Use of other practical "n" values will be permitted by the plan reviewing agency for longer pipe sections if deemed justifiable on the basis of research or field data presented.

Under exceptional conditions, if full and justifiable reasons be given, and if special arrangements be available or will be provided for flushing, velocities as low as 1.6 feet per second may be permitted. In general, the following minimum grades should be provided:

	Percent
8-inch sewers	0.40
10-inch sewers	0.28
12-inch sewers	0.22

The use of a larger sewer to take advantage of the lesser minimum slope, when there is not enough sewage to fill the sewer nearly one-half full, is generally not advisable. The use of asbestos-cement pipe or enamel-lined or cement-lined cast-iron pipe is suggested under such conditions.

Sewer lines must be laid on straight alignment and uniform slope between manholes. Manholes should be placed on sewers at all points of change of slope or alignment, at the upper ends of all sewer lines, and otherwise at intervals not greater than 400 feet. If the topography be very uneven and frequent changes in alignment and slope be necessary, a limited number of lampholes may be substituted for manholes at such points of change. Not more than one lamphole should be placed between two successive manholes.

There must be no permanent physical connection between a public or private potable-water supply system and a sewer, sewage-disposal system, or appurtenances thereto, which would render possible the passage of any sewage or polluted water into the potable-water supply.

Grease Traps

Premature failures of septic-tank systems are sometimes due to accumulations of grease within the tanks. Sewer lines frequently clog because of grease collections. When grease traps are used, the grease must be removed at frequent intervals. Grease traps may be used on kitchen wastelines from institutions, hotels, restaurants, schools with lunchrooms, and other places where the volume of kitchen wastes is large. After passing through the grease trap, the kitchen wastes must still be treated in the septic tank before being discharged to the disposal area. Wastes from garbage-grinders should not be discharged to a grease trap. (Grease traps have been used with some degree of success for the removal of lints from laundry wastes, but better results may be obtained by increasing the size of the septic tanks receiving such wastes, or by the use of rock filters to remove the lint.)

Location

Grease traps should be placed at a location that is readily accessible for cleaning, and close to the fixture discharging greasy wastes.

Construction Details

The most important considerations for design of grease traps are:

1. Capacity of the trap.

2. Facilities for insuring that both the inlet and outlet are properly trapped.

3. Ease and convenience with which the traps can be cleaned and the accumulated grease removed.

4. Inaccessibility of the traps to insects and vermin.

5. Distance between inlet and outlet, which should be sufficient to allow gravity-differential separation of the grease, so that it will not escape through the outlet.

The principles are illustrated in figure 22.

Flow-control fittings should be installed on the inlet side of smaller traps to protect against overloading or sudden surges from the sink or other fixtures. Venting is not necessary in the large, outdoor traps, where siphonage of the contents can be prevented by providing outlets of liberal size. Where efficient removal of grease is very important, use has been made of an improved 2-chamber trap which has a primary (or grease-separating) chamber and a secondary (or grease-storage) chamber. By placing the trap as close as possible to the source of wastes, where the wastes are still hot, the separating grease at the surface may be removed by means of an adjustable weir and conveyed to the separate secondary chamber, where it accumulates, cools, and solidifies.

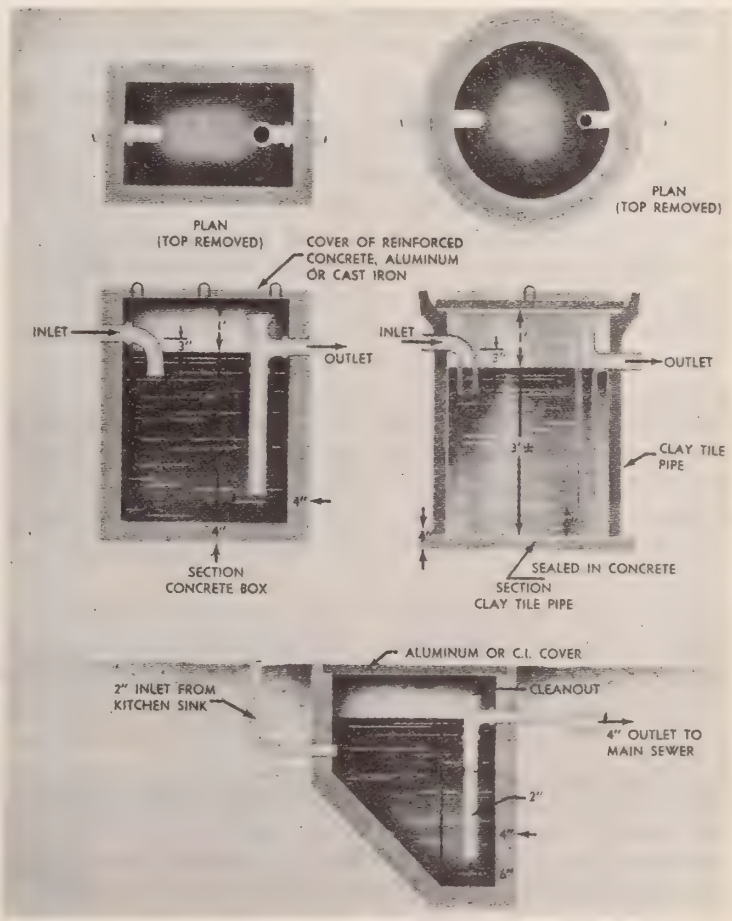


Figure 22.--Typical grease traps.

Capacity

Selection of size of traps should be based on verified efficiency ratings and flow capacities. The required flow capacities should be based upon the number and kind of sinks or fixtures discharging to the trap. In addition, a grease trap should be rated on its accumulated-grease capacity, which is the amount of grease (in pounds) that the traps can hold before its average efficiency drops below 90 percent. It is commonly regarded that the grease-retaining capacity in pounds should equal at least twice the flow rating in gallons per minute. That is to say, a trap rated at 20 g. p. m. should retain at least 90 percent of the grease discharged to it until it holds at least 40 pounds of grease. Most manufacturers of commercial traps rate their products in accordance with this procedure.

Recommended minimum flow-rate capacities of traps connected to different types of fixtures aregiven in Table 16.

Table 16. Recommended ratings for commercial grease traps

Type of fixture	Rate of flow, in g. p. m.	Grease retention capacity rating, in pounds	Recommended maximum capacity of fixture connected to trap, in gallons
Restaurant kitchen sink ---------	15	30	37.5
Single-compartment scullery sink	20	40	50.0
Double-compartment scullery sink	25	50	62.5
2 single-compartment sinks------	25	50	62.5
2 double-compartment sinks -----	35	70	87.5
Dishwashers for restaurants:			
Up to 30 gal. water capacity --	15	30	37.5
30 to 50 gal. water capacity --	25	50	62.5
50 to 100 gal. water capacity --	40	80	100.0

A net capacity of 2 1/2 gallons per person has been found large enough to hold the flow from one meal long enough to accomplish proper grease separation. The minimum allowable capacity should be about 125 gallons for small installations serving up to about 50 people with proportionately larger capacities for larger populations. As with septic tanks, however, it is generally good economy to build grease traps somewhat oversize. For installations too small to justify a 125-gallon grease trap, best results can usually be obtained by applying available funds to an oversized and properly fitted septic tank.

Operation

In order to be effective, grease traps must be operated properly and cleaned regularly to prevent the escape of appreciable quantities of grease into the septic tank. The frequency of cleaning at any given installation can best be determined by experience based on observation over selected typical periods of use. Generally, cleaning should be done when 75 percent of the grease-retention capacity is filled with accumulated grease.

Grease traps must be kept tightly covered to prevent odor nuisances and to exclude insects and vermin. Grease removed from the traps is disposed of by burial. (It may be used for making soap and glycerine, and for other manufacturing purposes, when economically feasible or because of shortages of such materials during wartime.)

Septic Tanks for Institutional Systems

Septic tanks of two compartments give better results than single-compartment tanks. Although single-compartment tanks are acceptable for small household installations, tanks with two or more compartments should be provided for the larger institutional systems. Tanks with more than two compartments are installed infrequently.

The compartments should be separated by walls containing ports or ell fittings at proper elevations. In the selection of these elevations, the general principles apply as in the design of outlet fittings. Vents for the passage of gases from one compartment to another should also

be included.

In a two-compartment tank, the compartment nearest the outlet is used both as a settling basin and as an observation well. The relative absence of solid material in the second compartment serves as an indication that the tank is functioning properly, although it may not serve as an index of conditions within the first compartment, and it is sometimes advisable to clean the first compartment before accumulations in the second become appreciable. In a two-compartment tank, the first compartment should have a capacity at least two to three times the capacity of the second compartment.

Whatever the number of compartments, means should be provided for gaining access to each compartment, and for measuring the depths of sludge and scum at the outlet device as illustrated in figure 19. Unless tops of septic tanks be near the surface of the ground, as in figure 16, manholes should be provided as required to facilitate ingress and egress. A single manhole above a dividing wall may be used for gaining access to two compartments in a multicompartment tank. Manholes are also desirable over the inlet and outlet devices.

Alternate designs for manholes are shown in figure 15. The design selected will depend on whether or not the manhole cover must be flush with the surface, and on the anticipated traffic loadings over the area.

The effect of a multiple-compartment tank can be accomplished by using two or three tanks in series. A better construction arrangement, particularly for medium or large installations, is to connect special tank sections together into a unit having single end-walls and two compartments. A unit of four precast tank sections forming two compartments is shown in figure 23. For operational reasons, it is recommended that the number of compartments or tanks in series be limited to four.

Capacities

The net volume or effective capacity below the flowline of a septic tank, for flows up to 500 gallons per day, should be at least 750 gallons. For flows between 500 to 1500 gallons per day, the capacity of the tank should be equal to at least 1-1/2 days' sewage flow. With flows greater than 1500 gallons per day, the minimum effective tank capacity should equal 1125 gallons plus 75 percent of the daily sewage flow; or

$$V = 1125 + 0.75Q$$

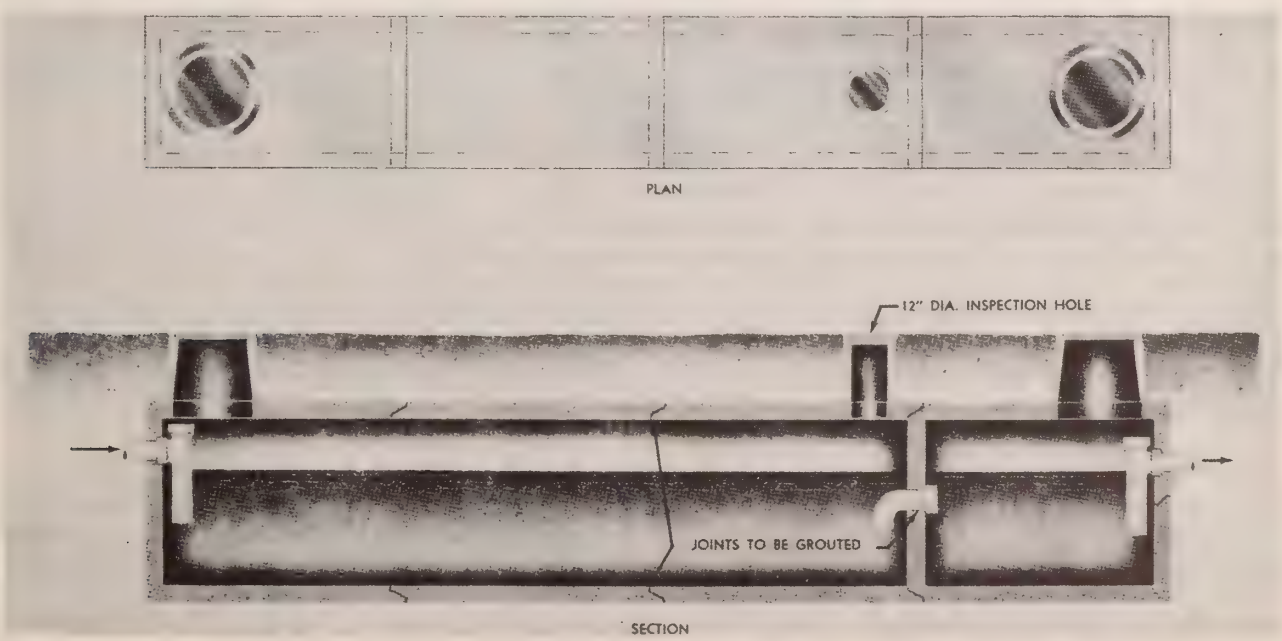


Figure 23.--Battery of four precast reinforced-concrete septic-tank sections.

where V is the net volume of the tank in gallons and Q is the daily sewage flow in gallons. Recommended tank capacities for flows up to 14,500 gallons per day may also be obtained from figure 24. For higher flows of up to about 100,000 gallons per day, Imhoff tanks may be more satisfactory than septic tanks for primary treatment. For flows above 100,000 gallons, still other types of sedimentation tanks may be more economical. These fall within the category of design for municipal systems, and are beyond the scope of this manual.

Dosing Tanks

When the quantity of sewage exceeds the amount that can be disposed of in about 500 lineal feet of tile, a dosing tank should be used in conjunction with the septic tank, in order to obtain proper distribution of sewage throughout the disposal area and give the absorption bed a chance to rest or dry out between dosings. Rest periods are always advantageous, especially when the soil is dense. The dosing tank should be equipped with an automatic siphon which discharges the tank once every 3 or 4 hours. The tank should have a capacity equal to about 60 to 75 percent of the interior capacity of the tile to be dosed at one time.

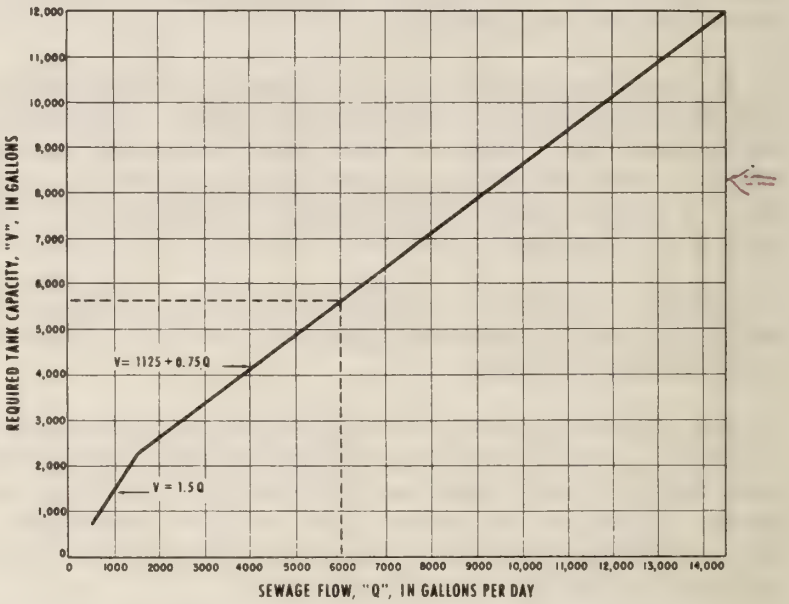


Figure 24.--Septic-tank capacities for sewage flows up to 14,500 gallons per day.

Where the total length of tile laterals exceeds 1,000 feet, the dosing tank should generally be provided with two siphons dosing alternately and each serving one-half of the tile field. The proper design of dosing devices involves hydraulic problems and head losses which must be carefully considered. Dosing siphons require operating heads ranging from about 5 feet down to a minimum of 1 or 2 feet, and repeated studies of different layouts may be necessary in order to arrive at an economical design in which available head is conserved and best use is made of existing conditions of topography. Special siphons are manufactured for low head losses. For details and capacities, the manufacturers' bulletins should be consulted.

Special care must be taken in the installation of siphons. All dimensions and elevations should be carefully followed, and no changes should be made without prior approval by the engineer or manufacturer. Tests should be made to determine that there be no air leaks, either in the piping or bell casting, and if leaks be found, they should be repaired. Leaks may be detected by filling the dosing tank with water, to a point where the bell and piping connections are covered, and observing the water surface for rising bubbles. New siphons should be primed by filling with water when the system is first started anyway, and the tests for leakage can be made at that time.

When properly installed, automatic dosing siphons will give satisfactory service. They contain no moving parts and are more foolproof than any dosing device that depends upon moving parts for its operation. Figure 26 shows a septic tank and dosing compartment with alternating siphons, as illustrated in suggested plans and designs developed by a State health department.

A typical layout plan or "general plan" of a system using alternating siphons is illustrated in Figure 27.

Separate siphon compartments already equipped with siphons are made by some manufacturers.

Duplex siphon compartments equipped with two siphons which operate alternately are also prefabricated.

If the head available is inadequate to permit the use of a siphon, intermittent pump operation may be used to obtain proper dosing of the field, as shown in Figure 28. The pump discharge lines may be cross-connected to obtain flexibility and to facilitate operations when one pump is down for repairs.

If the ground be flat, the use of a dosing chamber for large groups of people would bring the subsurface tile drains too deep for effective action. In such a case, the disposal field should be made large and divided into two parts for alternative use, or a sewage ejector might be used instead of a siphon. Figure 25.

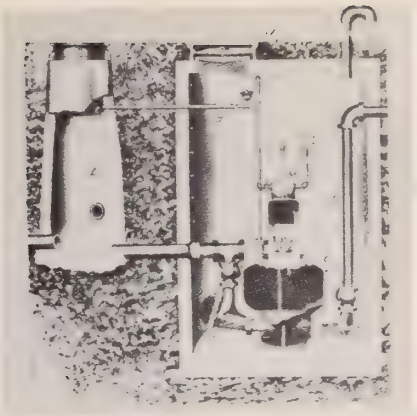


Fig. 25 Pneumatic Sewage Ejector
a. Ground surface b. Manhole
c. Ejector d. Air Compressor
e., f. Valves g. Air Relief Line
h. Pressure Sewage Line to Septic Tank

Sand-Filter Trenches

In permeable soil, absorption trenches of the type illustrated in Figure 5 or seepage pits as illustrated in Figure 7 provide the best underground method of disposing of the effluent from a septic tank. The absorption trench is preferred, and is required in some areas where seepage pits are prohibited. In soil that is relatively impermeable, however, neither absorption trenches nor seepage pits are satisfactory. They become more expensive as the soil permeability decreases, and may not be economically feasible when the percolation time exceeds 30 or 40 minutes per inch. The exact point at which they are no longer desirable will depend largely upon the relative costs of labor and material in the locality where the disposal system is to be constructed. The decision as to whether to use absorption trenches or seepage pits may also depend upon the area available. Where land is at a premium, absorption trenches become less attractive. They begin to require excessive areas when the percolation time exceeds 20 minutes per inch.

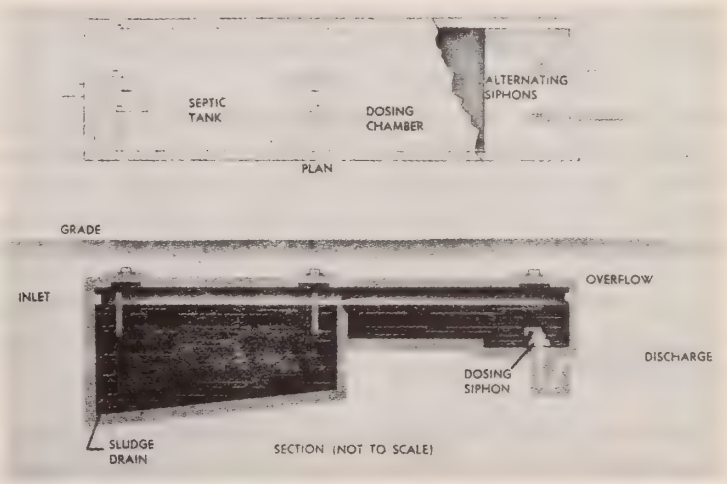


Figure 26. --Septic tank and dosing tank with alternating siphons.

When absorption trenches and seepage pits are impractical for institutional or similar use, the possibility of treating the tank effluent in subsurface sand-filter trenches may be considered.

The filter trenches are somewhat similar to absorption trenches, the major difference being that the filter trenches are deeper, generally somewhat wider, contain an intermediate layer of sand as filtering material, and are provided with underdrains for carrying off the filtered sewage. The tank effluent is not absorbed, except to a limited extent. It is simply filtered and must be disposed of when it leaves the trench. For this reason, filter trenches are properly regarded as a means of sewage treatment, and not sewage disposal. They accomplish a high degree of puri-

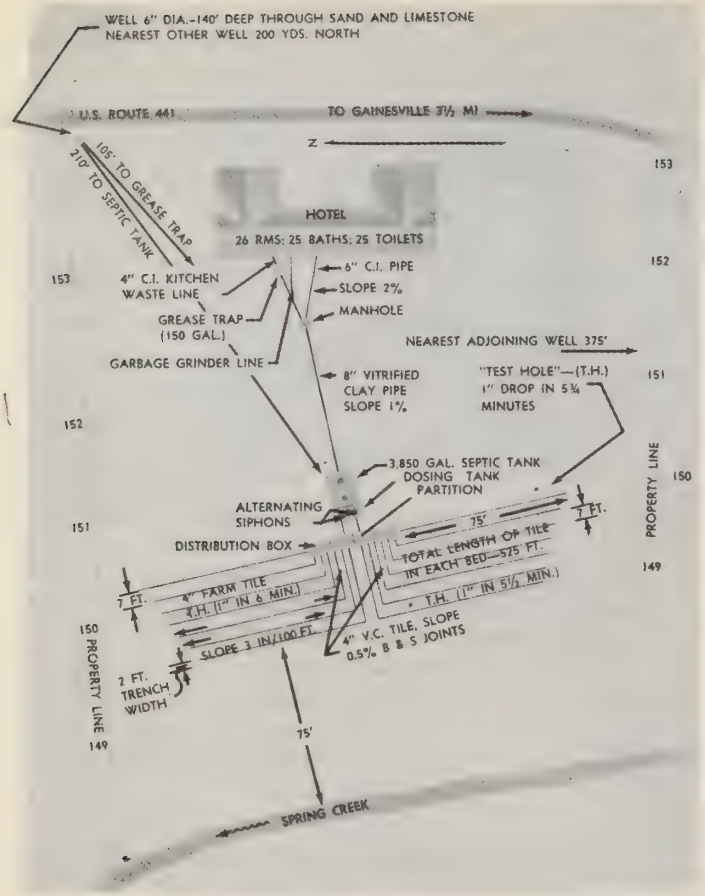


Figure 27. --Typical layout plan of a subsurface sewage-disposal system.

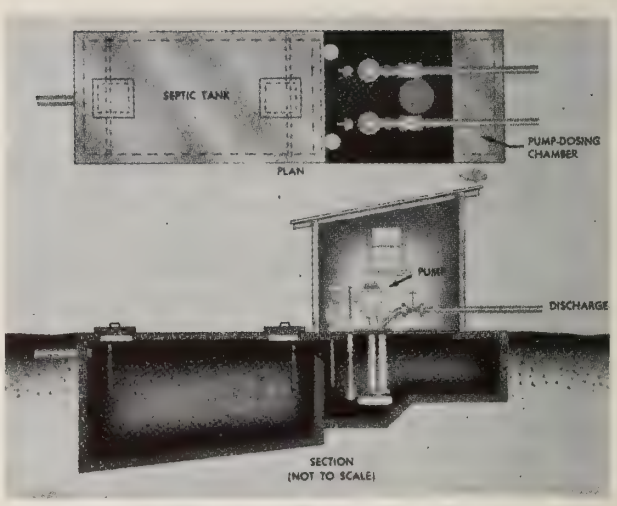


Figure 28. --Septic tank and pump-dosing chamber.

fication, however, and the sewage effluent coming from a filter trench that is properly designed can sometimes be disposed of without further treatment, by discharging into ditches, small streams, or dry streambeds. If the receiving stream contributes to a source of water supply, shellfish-growing area, or recreational area, chlorination should be required as hereinafter explained. In some jurisdictions, chlorination is required for all effluents from sand filters.

Nuisances are likely to be created where there are large institutions or a number of homes discharging effluents into a single ditch. In such cases, it may be advisable to lay sewers or covered drains in the ditch.

Approval should be obtained from the State or local health department before filter trenches are installed. This method of sewage treatment becomes less economical and less desirable as the quantity of sewage and the required area increase. Subsurface sand filters may be needed for larger installations.

Design Data For Disposal System For Hotel Illustrated in Figure 27.

26 rooms total

20 rooms with private baths x 2 persons per room x 60 gal. per person per day	= 2,400 gal. per day
6 rooms with connecting baths x 2 persons per room x 50 gal. per person per day	= 600 gal. per day
5 daytime employees x 25 gal. per person per day	= 125 gal. per day
2 night employees x 25 gal. per person per day	= 50 gal. per day
Kitchen wastes: 60 persons x 3 meals per day x 2-1/2 gal. per meal	= 450 gal. per day
Total daily sewage flow	= 3,625 gal. per day

Required septic-tank capacity (from Fig. 22) 3,850 gal.
Required grease-trap capacity 60 persons x 2-1/2 gal. 150 gal.
Percolation test: 6 min. per inch drop
Allowable rate of sewage application (from Fig. 18):
2.1 gal. per sq. ft. per day

Trench area required for normal wastes $= \frac{3,625}{2.1} = 1,725$ sq. ft.

Plus 20% additional for wastes from garbage grinder 345 sq. ft.
Total trench area required 2,070 sq. ft.

Desired trench width: 24 inches (2.0 ft.)

Total trench length $= \frac{2,070}{2} = 1,035$ ft.

Dosing tank, alternating siphons, and twin fields required.

Each of the two trench fields would be $\frac{1,035}{2}$ or 518 feet long.

Maximum trench length is 100 ft.; the desired length is 50 to 60 ft. In this case, 75 ft. lengths can best be worked into the available disposal area with room for future additions if needed. Therefore, the number of 4" laterals required for each of the two fields would be $\frac{518}{75}$ or 7 lateral lines.

The preferred dosing tank capacity is 75% of the interior capacity of the tile piping to be dosed at one time. Therefore, 3.14 x 4" tile x 12" lengths = 151 cubic inches per foot of tile piping.

Therefore, $\frac{151 \times 0.75}{231 \text{ cu. in. per gal.}} = 0.5$ gal. per foot required dosing-tank capacity.

Thus, the capacity of the dosing tank should be:
0.5 gal. per ft. x 7 x 75 ft. = 260 gallons.

Construction Features

Typical details of an underdrained sand-filter trench are shown in Figure 29. For all-year service, filter trenches should be designed for filtration rates as given in Table 17.

Table 17. Loading rates for subsurface filters

Type of service	Area requirements		
	Square feet per bedroom	Gallons per acre per day	Gallons per square feet per day
Without garbage-grinder or automatic washer	150	50,000	1.15
With garbage-grinder ----------	180	41,500	0.95
With automatic washing machine ----------	200	50,000	1.15
With both garbage-grinder and automatic washer	240	41,500	0.95

The filtering material should be clean, coarse sand, all passing a screen having four meshes to the inch. The sand preferably should have an effective size between 0.4 and 0.6 mm. Since it is frequently difficult to obtain sand of this large size, an effective size as small as 0.25 mm. may be acceptable. The coarser sands will last much longer. Fine sand will lead to premature clogging and a need for replacement. The sand should be not less than 2 feet deep.

Tile distributors, above and below the sand, should be surrounded by coarse-screened gravel or crushed stone. All of the gravel or stone should pass a 2 1/2-inch screen and should be retained on a 3/4-inch screen. Fine gravel, down to 1/4-inch, may be used above and around the coarse material, both at the distributors and at the underdrains.

The slope of the distributors should be about 0.5 percent where dosing tanks are not used, and the slope of the underdrains about 0.5 to 1.0 percent. It is essential that the sand be thoroughly settled by flooding or other means before the distributors are placed at the final grade. The underdrains may be of agricultural tile or bell-and-spigot pipe, whereas perforated pipe is recommended for the distributors.

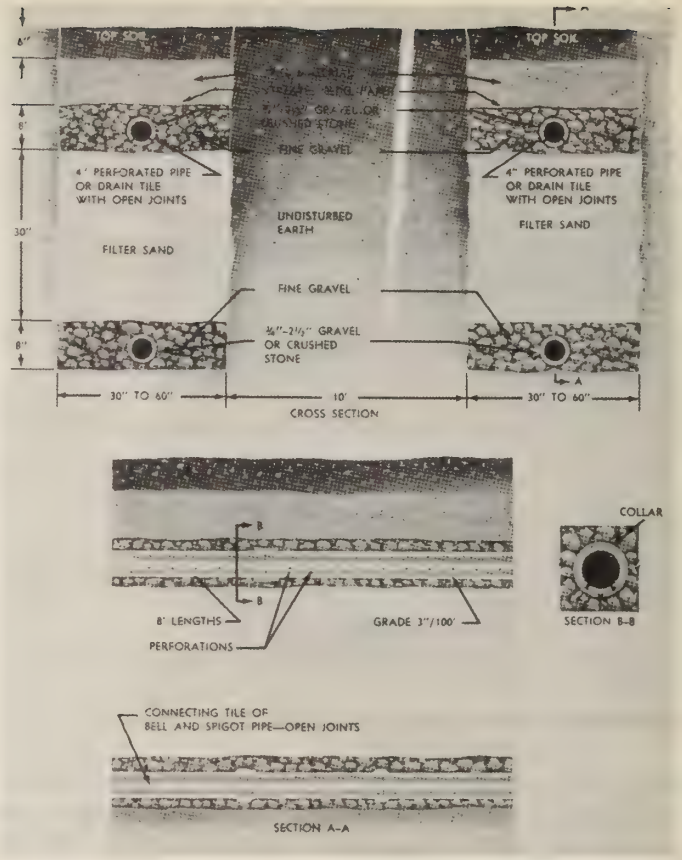


Figure 29. --Underdrained sand-filter trench.

Subsurface Sand Filters

As indicated previously, filter trenches are not economical for large installations. Subsurface sand filters are cheaper. They require less area, and will do the job just as well as filter trenches. They require more care in design and construction, but this is more than offset by savings in cost. As a rough guide, filter trenches are impracticable when the amount of sewage (and consequently the filter area or the length of tile distributors) is enough to require the use of dosing siphons. Subsurface sand filters are generally indicated when dosing siphons are needed in conjunction with artificial filtration.

The principles of design of subsurface sand filters are similar to the fundamentals involved in the layout of filter trenches. Both types of installations have distributors and underdrains, with filter sand between. The essential difference in the two is that filter trenches are smaller and the filter material is laid in trenches, as implied in the name. When two or more trenches are used, natural earth is permitted to remain between them. For subsurface sand filters, on the other hand, the entire filtration area is filled in artificially. A typical plan and section of a subsurface sand filter are illustrated in Figure 30.

Construction Features

The sand in a subsurface filter should be of a quality at least equal to that specified for a filter trench, with an effective size preferably between 0.4 and 0.6 mm, and never less than

* The effective size of a sand is that size of which 10% by weight is smaller. Uniformity coefficient is the ratio of that size of which 60% is smaller to the effective size.

0.25 mm, and with a uniformity coefficient less than 4.0. The gravel or crushed stone should likewise be equal to the quality previously specified. The same depth of sand is used, and the required filter area is the same as given in Table 17 with one exception: Where filters are constructed solely for seasonal use and have long rest periods over the greater part of the year, they may be expected to work satisfactorily at rates as high as twice those given in Table 17 provided that the sand has an effective size no smaller than 0.4 mm.

Dosing tanks should be provided where the total filter area exceeds 1800 square feet and where the distributors exceed 300 lineal feet. The size of the dose, or the net capacity of the dosing tank, should be 60 to 75 percent of the volume of the distributors dosed at one time. When an installation has over 1,000 feet of distributors, best results can be obtained by constructing the filter in two or more sections, dosed separately by alternating siphons.

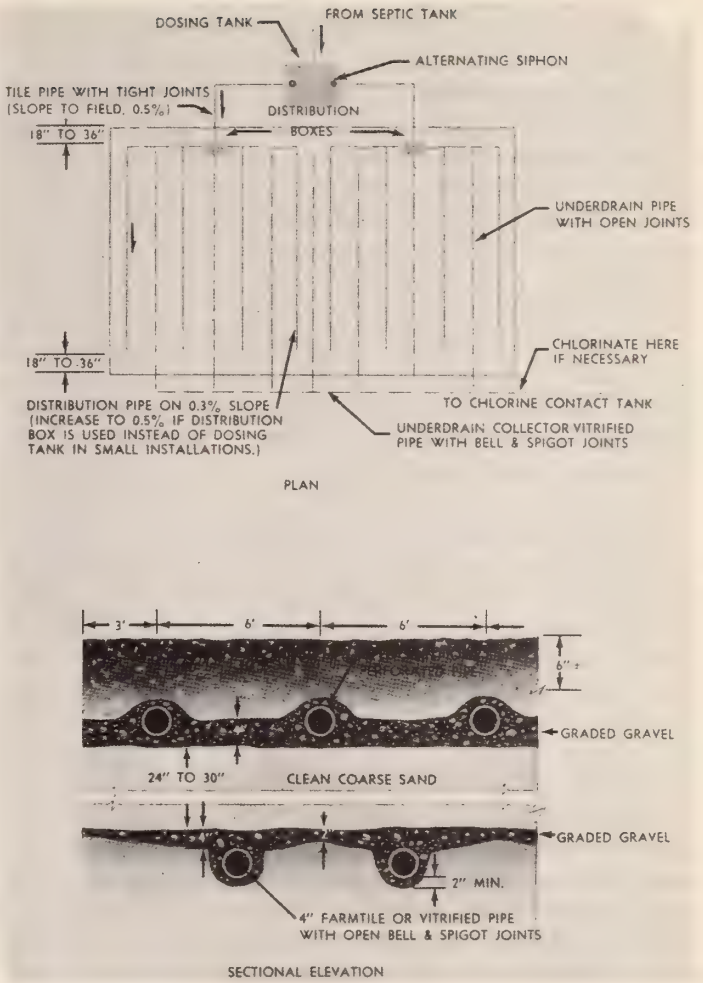

DOSING TANK
FROM SEPTIC TANK
ALTERNATING SIPHON
TILE PIPE WITH TIGHT JOINTS (SLOPE TO FIELD, 0.5%)
DISTRIBUTION BOXES
18" TO 36"
UNDERDRAIN PIPE WITH OPEN JOINTS
CHLORINATE HERE IF NECESSARY
18" TO 36"
DISTRIBUTION PIPE ON 0.3% SLOPE (INCREASE TO 0.5% IF DISTRIBUTION BOX IS USED INSTEAD OF DOSING TANK IN SMALL INSTALLATIONS.)
TO CHLORINE CONTACT TANK
UNDERDRAIN COLLECTOR VITRIFIED PIPE WITH BELL & SPIGOT JOINTS
PLAN
3'
6'
6'
6" ±
GRADED GRAVEL
24" TO 30"
CLEAN COARSE SAND
GRADED GRAVEL
2" MIN.
4" FARMTILE OR VITRIFIED PIPE WITH OPEN BELL & SPIGOT JOINTS
SECTIONAL ELEVATION

Figure 30. --Typical plan and section of a subsurface sand filter.

Underdrains may be of agricultural tile or bell-and-spigot pipe; the latter is preferred. Perforated pipe is recommended for distributors. Special joints of the precast, sleeve coupling, and taper coupling types are available which insure alignment of the pipe lengths. If farm tile be used for distributor laterals, it may be laid on grade boards. In any event, the distributors should be laid accurately to grade after the filter sand has been thoroughly settled by flooding or other means.

Where dosing tanks are used, the distributors should be laid to 0.3 percent grade; otherwise, they are laid to a grade of about 0.5 percent.

Superficial Sand Filters

In some areas, the ground-water table is too near the surface to permit construction or successful operation of any subsurface method of sewage disposal. The construction of buildings and sewage-disposal systems should generally be avoided in such places. Sometimes, however, the elevation of the water table may be found to fluctuate over a wide range unexpectedly. Through floods or other hydrologic conditions, areas which, for decades, may have experienced a water table appreciably below the ground surface may suddenly be faced with a condition wherein the ground water approaches or even covers the surface. Sometimes such occurrences are brought about artificially, as by the construction of dams or dikes, and the conditions may be likely to remain relatively permanent.

As previously explained, impervious soil may also preclude subsurface methods of disposal, and the occurrence of solid rock at or just below the surface of the ground may make subsurface treatment methods uneconomical.

In these events, it may be necessary to forego completely the construction or renovation of

subsurface methods of sewage treatment and disposal. The circumstances may require treatment and disposal by superficial means above the surface of the ground. This frequently necessitates pumping, but can be accomplished in superficial sand filters constructed as shown in Figure 31 except that the ends and sides must be surrounded by a masonry wall or earth dike for retaining the filter bed. The filters may be completely above the ground or only partly above the surface, depending primarily upon the depth to ground water or the depth to solid rock, as the case may be.

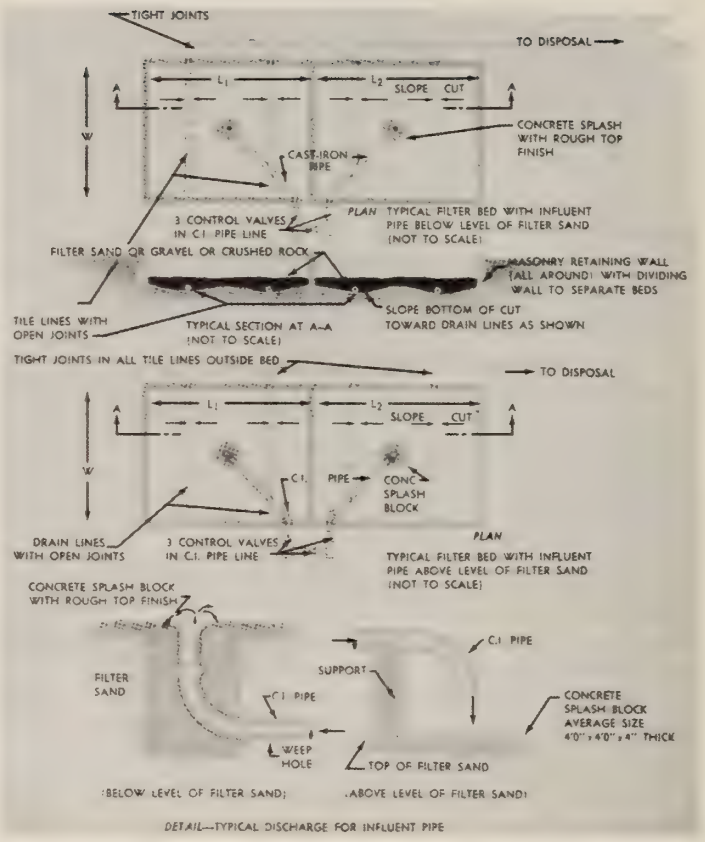

TIGHT JOINTS
TO DISPOSAL
SLOPE CUT
CONCRETE SPLASH WITH ROUGH TOP FINISH
CAST-IRON PIPE
3 CONTROL VALVES IN C.I. PIPE LINE
PLAN TYPICAL FILTER BED WITH INFLUENT PIPE BELOW LEVEL OF FILTER SAND (NOT TO SCALE)
FILTER SAND OR GRAVEL OR CRUSHED ROCK
MASONRY RETAINING WALL (ALL AROUND) WITH DIVIDING WALL TO SEPARATE BEDS
TILE LINES WITH OPEN JOINTS
TYPICAL SECTION AT A-A (NOT TO SCALE)
SLOPE BOTTOM OF CUT TOWARD DRAIN LINES AS SHOWN
TIGHT JOINTS IN ALL TILE LINES OUTSIDE BED
TO DISPOSAL
C.I. PIPE
CONC. SPLASH BLOCK
DRAIN LINES WITH OPEN JOINTS
3 CONTROL VALVES IN C.I. PIPE LINE
PLAN
TYPICAL FILTER BED WITH INFLUENT PIPE ABOVE LEVEL OF FILTER SAND (NOT TO SCALE)
CONCRETE SPLASH BLOCK WITH ROUGH TOP FINISH
C.I. PIPE
SUPPORT
FILTER SAND
C.I. PIPE
CONCRETE SPLASH BLOCK AVERAGE SIZE 4'0" x 4'0" x 4" THICK
WEEP HOLE
TOP OF FILTER SAND
(BELOW LEVEL OF FILTER SAND)
(ABOVE LEVEL OF FILTER SAND)
DETAIL—TYPICAL DISCHARGE FOR INFLUENT PIPE

Figure 31.--Open-filter-bed layout.

From the standpoint of operation, sewage filters do not have to be covered, but in built-up areas a shallow earth cover of about 6 inches is recommended, to prevent freezing in cold weather and to prevent emanation of odors and other nuisances from the septic sewage in warm weather. While open filters are accessible for cleaning and can be operated at higher rates than those covered with earth, they ordinarily require daily attention, and are not usually advisable for private installations where septic tanks are used. They are more suitable for municipalities and large institutions where sewage-plant operators are employed. In such cases, the filters generally follow a conventional primary-settling tank or secondary-treatment and secondary-settling tanks, and the method of distributing sewage onto open filters is different from that indicated for covered filters. Figure 31 illustrates a typical installation of open filter beds.

Open filters are operated intermittently and, thus, are known as intermittent sand filters. They should always be divided into two or more units. Sand specifications and depths are the same as for subsurface sand filters. Loading rates are influenced by temperature, effective size and uniformity coefficient of the filtering medium, and the characteristics of the sewage to be treated. The last depends largely upon the degree of pretreatment received by the influent to the filter, but, since this chapter is concerned only with septic-tank systems, pretreatment may be ruled out of consideration here. Table 18 gives recommended maximum loading rates for the effluents from septic tanks which do not receive wastes from garbage grinders or automatic washing machines.

Table 18. Recommended loading rates of septic-tank effluents on open sand filters with uniformity coefficients not over 4.0
(Gallons per acre per day*)

Region	Effective size of sand				
	0.2 mm.	0.3 mm.	0.4 mm.	0.5 mm.	0.6 mm.
Southern U. S. ----------	100,000	130,000	160,000	180,000	200,000
Northern U. S. ----------	80,000	100,000	120,000	140,000	160,000

*Multiply rates by 0.83 if garbage-grinders are used.

In addition to dosing by siphons or pumps, some open filters are dosed by means of hand-operated gates or valves. In some places, it has been customary to dose about once a day. Other plants operate with as many as 4 doses per filter per day, but some dose at long and irregular intervals of several days. With fine sands, filtration efficiencies are increased by loading twice daily. With coarse sand (0.45 mm and up), efficiencies are increased by loading more frequently than twice a day, but multiple loadings present a problem in obtaining adequate coverage of the bed. Spray nozzles and rotary distributors have been used with reasonable success as dosing devices in some small installations, but it has been found necessary to cover the surface of the sand with several inches of pea gravel in order to prevent disturbance of the surface sand.

Dosing tanks should have capacities that will provide for flooding the beds to depths of 2 to 4 inches. Discharge from the dosing tanks should at least equal the flow of the raw sewage.

Since various States have different requirements or policies regarding open filter installations, the State or local health department should always be consulted before filters of this type are designed.

Industrial Waste Treatment

Septic-tank systems are not employed for the treatment of industrial wastes from large manufacturing industries. In small industrial plants, septic-tank systems, assisted as needed by supplementary processes may be used advantageously either for treating wastes to render them suitable for final disposal by a larger disposal unit, or for conditioning wastes to render them acceptable for discharge to sewer systems where they would otherwise be objectionable.

It is important to note that the design of septic-tank systems for treatment and disposal of industrial wastes is not sufficiently simple to permit formulation of specific criteria for design. This is because industrial wastes vary widely in their composition; in fact, rarely do any two plants produce wastes of the same character and composition. The design of an industrial-waste treatment and disposal system is, therefore, a problem requiring specialized sanitary engineering consultation, and this consultation usually includes special laboratory analyses and studies of the particular wastes under consideration. With these precautions, however, it is possible, in many instances, to develop a workable septic-tank system which is actually simple, effective, economical, and within the means of the small industrial plant.

The following is intended to indicate only qualitatively some of the methods applicable to a few industrial wastes. The particular design for any given waste must be prepared by competent sanitary engineers.

Laundry Wastes and Other Greasy Wastes

Wastes derived from laundries and some other sources, which contain soaps, oil, and greases in relatively low concentrations, may be successfully disposed of by one of the methods previously described, provided the greasy substances are first removed. If greasy substances, including soaps and oils, are discharged into leaching systems, they accumulate and soon cause clogging of the soil pores.

The greasy substances contained in wastes are of two types: (1) the floatable greases, which are non-emulsified and which, therefore, upon quiescence or standing, will separate and rise to the surface of the liquid to form a surface layer; and (2) the emulsified greases, which do not separate upon standing. Both of these components may be present in considerable concentrations, and both must be removed. Properly designed, conventional grease traps, such as those used for restaurant wastes, will remove floatable grease, but not emulsified grease. Emulsified grease may be removed in a practical manner, however, either (1) by passing the waste through a rock filter, or (2) by chemically flocculating the waste.

Where relatively low concentrations of emulsified grease are present, the rock-filter process may be successfully used. The rock filter serves to de-emulsify the grease, changing it to floatable grease so that it may be subsequently removed by simple trapping. Septic-tank units may be employed advantageously both for trapping the floatable grease and to serve as the container for the rock filter. The servicing required for this system includes removal of the

accumulated floatable grease at regular intervals and occasional replacement of the filter rock. The sizes of the trap and rock-filter units will depend upon the quantity of the waste and its composition, as determined by laboratory analyses.

Where high concentrations of emulsified grease are present, a chemical flocculation process may be needed. For all of these processes (trapping, flocculation, and settling), septic tanks may be used as the most economical means of obtaining the necessary capacities. Also required, as accessories to the flocculation process, are a suitable electrically operated stirring device and a volumetric-type chemical feeder. Maintenance of the system includes keeping the chemical feeder stocked with chemicals and periodic pumping of accumulated sludge from the settling basin. In this process, the grease particles are agglomerated by the flocculating action into large particles which settle out in the settling basin. The sizes of the various tanks, the amounts of flocculating chemicals needed, and the frequency of pumping required will depend upon the quantity of the waste and its composition, as determined by laboratory analyses.

Slaughterhouse, Dairy, and Other Organic Wastes

These wastes are generally characterized by very high concentrations of organic materials, up to (and even exceeding) 100 times the strength of ordinary sewage. Part of the organic material is in true solution, and this may sometimes be disposed of by simple underground leaching, provided there is adequate area and provided a suitable schedule for resting the leaching areas is maintained. Much of the organic material, including the emulsified greases, is in colloidal suspension. Colloidal particles will clog underground leaching systems. They do not settle out on quiescence and, therefore, have to be removed by some means, such as by flocculation and sedimentation, or by application to trickling filters followed by settling. As in the preceding example, septic tanks may advantageously be used to provide the necessary tank capacities for the trapping, flocculating, and settling processes.

Mineral or Inorganic Wastes

Mineral and similar wastes present special problems generally requiring chemical neutralization or other chemical treatment before the wastes may be filtered or leached into the ground. Important factors are the metallic and nonmetallic ions present, their concentrations, and, for underground leaching, the nature and importance of the water basin lying below the area intended for leaching. Septic tanks can sometimes be used advantageously in the solution of these problems, as chemical reaction chambers, settling tanks, etc.

Chlorination

Filter trenches and artificial sand filters that are properly designed and operated will produce an effluent that is clear and sparkling, and the filtration will remove a high percentage of the bacteria contained in the sewage. Some of the remaining bacteria may still be capable of producing disease, however, and the sewage effluent must be disinfected if it be discharged to a ditch that is accessible to humans, or to a stream that contributes to a nearby source of water supply used for drinking, growing of shellfish, or swimming. Chlorine is the disinfectant most commonly used.

Present custom is to apply chlorine in the amount necessary to obtain a chlorine residual of 0.5 to 1.0 ppm after thorough mixing and 15 minutes contact at peak flows. On an average, this requires a chlorine dosage in the neighborhood of 6 ppm for sand-filter effluents. This is equivalent to 1/2-pound of available chlorine for every 10,000 gallons of sewage, or less than 1 ounce per 1000 gallons. Most States require a chlorine contact chamber large enough to retain the sewage for at least 15 minutes. A typical design is illustrated in Figure 32.

Chlorine may be obtained in steel cylinders in which the gas is compressed to a liquid state. It may also be obtained from sodium hypochlorite or calcium hypochlorite.

Sodium hypochlorite is obtainable only as a solution. Upon drying, it decomposes. Solutions of hypochlorite are obtainable in strenghts ranging from 1 percent to 15 percent of available chlorine. This material is corrosive to ordinary metals and should be handled in stoneware crocks. Wooden barrels may be used for temporary installations.

Calcium hypochlorite is obtainable only in a dry form, of which there are two principal types.

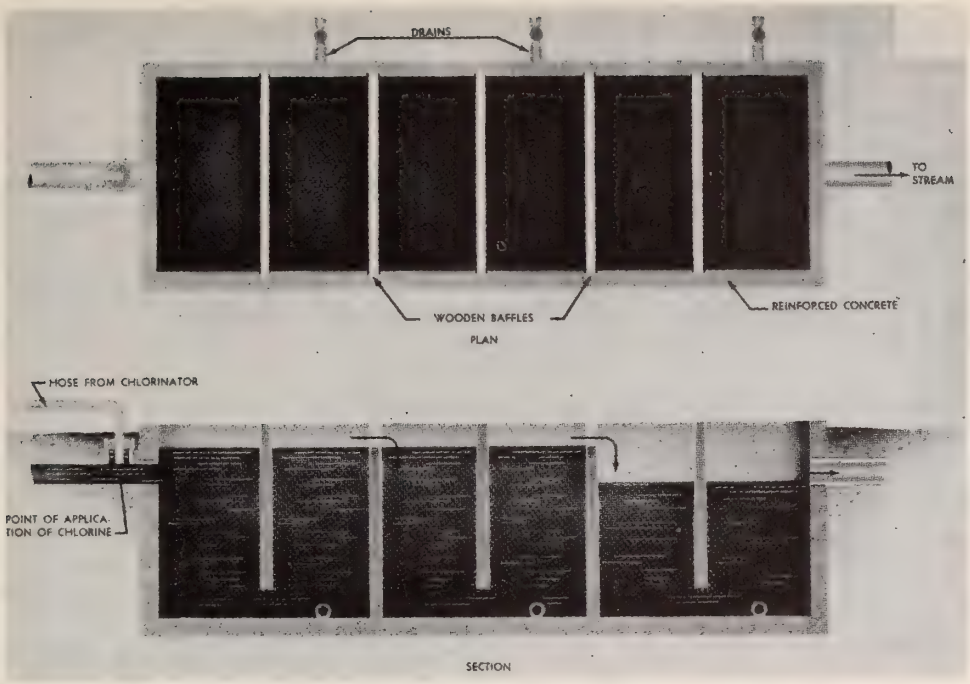


Figure 32.--Chlorine-contact chamber.

Hypochlorite of lime (or "bleaching powder") contains about 35 percent of available chlorine when manufactured, and high-test hypochlorite contains about 70 percent of available chlorine.

The ordinary hypochlorite of lime is really a mixture of compounds which may be largely a calcium oxychloride. It is not stable, and may lose a large percentage of its chlorine content if stored for long periods. When made into a water solution, it also has the undesirable characteristic of forming a scale of calcium carbonate which tends to clog the feeding apparatus. It is cheaper than high-test hypochlorite, however, and it can be used satisfactorily with certain types of feeding equipment, if large solution tanks be employed and if proper precautions be taken in the preparation and utilization of the solution. The undissolved portion must be allowed to settle out of the solution, and only the clear, supernatant liquid fed through the feeding apparatus.

High-test hypochlorite is a true calcium hypochlorite. It is more stable and more convenient to handle than ordinary hypochlorite of lime. It is available under several trade names, familiar to sanitary engineers and sanitarians. When made up with soft water in solutions containing 1 to 2 percent of available chlorine, calcium hypochlorite does not give much trouble with calcium-carbonate deposits, but precaution should still be taken to feed only the clear, supernatant portion of the solution through the feeding equipment. When hard water is used to make up the solution, the addition of a small quantity of sodium hexametaphosphate will help prevent deposits.

The decision between sodium hypochlorite or calcium hypochlorite should depend upon the relative costs of the two materials in the locality of the job. Information as to their costs can usually be obtained from the suppliers of the hypochlorinators.

The decision as to whether to apply chlorine as a gas or in liquid form as a hypochlorite is some times dependent on the availability of power. Most manufactured hypochlorinators require either electric current or clean water under pressure for their operation. In some remote places, these are not available. In such cases, chlorinators using chlorine in cylinders can be operated without any outside power source.

Usually, however, power is available and the decision as to whether to use hypochlorite or chlorine gas is dependent upon their relative cost. Gas is the cheaper of the two, but equipment for controlling it is much more expensive than simple hypochlorite feeders.

In general, hypochlorite is preferred when the amount of chlorine required is less than 2 or 3 pounds per day. In other words, hypochlorite would normally be used for disinfecting the effluent from a sand sewage filter for sewage flows up to about 50,000 gallons per day. For chlorinating a septic-tank effluent, the sewage-flow limit for hypochlorinators would be about 10,000 gallons per day. Beyond these quantities, savings in the cost of the chlorine gas will usually offset the more-expensive original investment in equipment.

Several satisfactory types of hypochlorinators are available. Various types of chlorinators are also made. Both kinds of apparatus are being gradually improved. Both require occasional maintenance. Therefore, in choosing the make of apparatus to be purchased, the first consideration should be that of service. It is practically always advisable to purchase a chlorinator from a manufacturer who has a full-time serviceman traveling through the area where it is to be used. Jobbers and agents handling chlorinators are seldom qualified to furnish the best technical assistance, and are usually unable to render the prompt service that is necessary when a chlorinator gets out of order.

Wherever chlorination is necessary, daily tests should be made to determine the amount of chlorine residual after the requisite contact period. Many health departments require monthly reports giving the results of the tests.

The test is simple. It is usually made by adding a small amount of standard orthotolidine solution to a sample of the effluent and comparing the color developed with color standards which may be obtained with the solution from most laboratory supply houses. If the color of the sample changes to an orange-yellow hue, it indicates that chlorine is being applied in a proper amount.

Non-water Carriage Sewage Disposal Methods

Earth Pit Privy.

An earth pit privy is a device for the disposal of human excreta in a pit in the earth. The pit is covered by a structure affording privacy and shelter and containing a covered seat with an opening into the pit.

The earth pit privy offers a suitable type of sanitary excreta disposal unit for the individual rural home, and in recreational areas where water carriage systems of disposal cannot be provided. In 1940, 114,000 of the 200,000 rural school buildings in the United States were still of the one-room type and were served by non-water carriage sewage disposal units. While there are many different designs in use, the basic elements of the sanitary types are the same in all cases. This no longer pertains to the U. S., but does in the economically underdeveloped countries.

The earth pit should be of such capacity that it may be used for several years without requiring the privy to be moved. Excreta and toilet paper are deposited directly into the pit. The bacterial action in a pit is both aerobic and anaerobic. In the upper (often liquid) layer the aerobic bacteria predominate, while in the lower (sludgy) layer there is a good deal of anaerobic action. The fluid material that seeps out of the pit is subject to the aerobic nitrifying action of the bacteria in the soil. If the conditions in the pit make it difficult for the aerobic process, the odor from the anaerobic process which supervenes may create a disturbing nuisance. The pit should be within the depth of the bacterial zone of the soil, and therefore be not deeper than four to five feet.

Insects, animals, and surface water are excluded from access to the pit to prevent the spread of intestinal diseases. It is essential that the privy be designed and constructed so that the pit can be maintained flytight.

The location of the privy should be such as to minimize danger of contamination of water supplies. A safe distance from springs or wells depends upon the nature of the soil. The distance may be shorter where the soil is sandy and longer where the soil is clayey and the filtration of fluid inadequate to insure safety. In limestone regions where crevices are prevalent or potentially present, distances must be even longer. Under ordinary conditions the privy should be located at least 50 feet from any well, spring, or other source of water supply. On level ground, the area around both privy and water supply should be mounded with earth. When any doubt exists as to the safety of the water supply if an earth pit privy be used, other types of disposal should be considered.

The site should be accessible to the user, ordinarily not less than 50 feet nor more than 150 feet from the buildings served. Consideration should be given to the direction of prevailing winds to reduce fly and other nuisance. The privy pit should not encroach within 6 feet of any building line or fence to allow proper construction and maintenance.

Pit, sill, and mound. A minimum capacity of 50 cubic feet for the average family is recommended. This pit should be tightly sheathed for several feet below the earth surface, but openings in the sheathing are desirable below this depth. The sheathing should extend only one to two inches below the top of the sill in order that the weight of floor and building will rest on the sill only. This sill should preferably be of reinforced concrete and be placed on firm undisturbed earth. In areas where mosquitoes are nuisances, a cupful of kerosene, poured into the pit each week during the summer season is recommended to prevent mosquito breeding. It is also recommended that toilet paper instead of other heavy papers be used to prevent the pit from filling up too rapidly.

An earth mound at least equal in thickness to the concrete sill should be constructed, having a level area extending for 18 inches away from the sill in all directions. (Fig. 33)

Floor and riser. Impervious materials such as concrete are believed to be most suitable for floor and riser. Because privy units are commonly used as urinals, the use of impervious materials for risers is desirable in the interest of cleanliness. In cold climates, wood treated with a preservative such as creosote has been found to be durable and to reduce the problem of condensation. Therefore, in some sections of the country wood may be used if approved by the department of health.

Seat and Lid. The lid should be hinged to permit raising, and likewise the seat may be provided with hinges. Material used in construction should be light in weight but durable. Seats should be comfortable. Lids need not necessarily be self-closing. Separate seats with smaller openings for small children are preferable to a separate smaller riser unit. Such extra seats need not be attached to the unit but may be placed on top of the standard seat. Two objections to self-closing seat lids are the discomfort to the user in having the lid rest on the upper portion of the back and the contact of the oftentimes soiled or frost-covered bottom surface of the lid with the user's clothing. A seat lid has been devised to overcome these objections. (See Fig. 34) This lid is raised to a vertical position by lifting it from the rear end so that tne top surface of the lid faces the user rather than the bottom surface which is normally exposed to the pit.

With hinged seat and lid and impervious riser construction there should be little need for urinal troughs. Such troughs in most instances are not constructed so that they can be maintained watertight, thus permitting very undesirable and unsanitary conditions to develop within the building. Where proper trough construction is provided the connection to the pit often permits all gases to be vented through the building. It is therefore recommended that the riser and seat construction be so installed as to make the use of urinal troughs unnecessary.

Vent. Venting practices differ in many parts of the United States because of differences in climatic conditions. In some States, particularly those in the South, vents have been omitted entirely and results from this practice appear to be satisfactory. Vents may pass vertically from either the pit or the riser through the roof or directly through the wall near the floor; the vertical

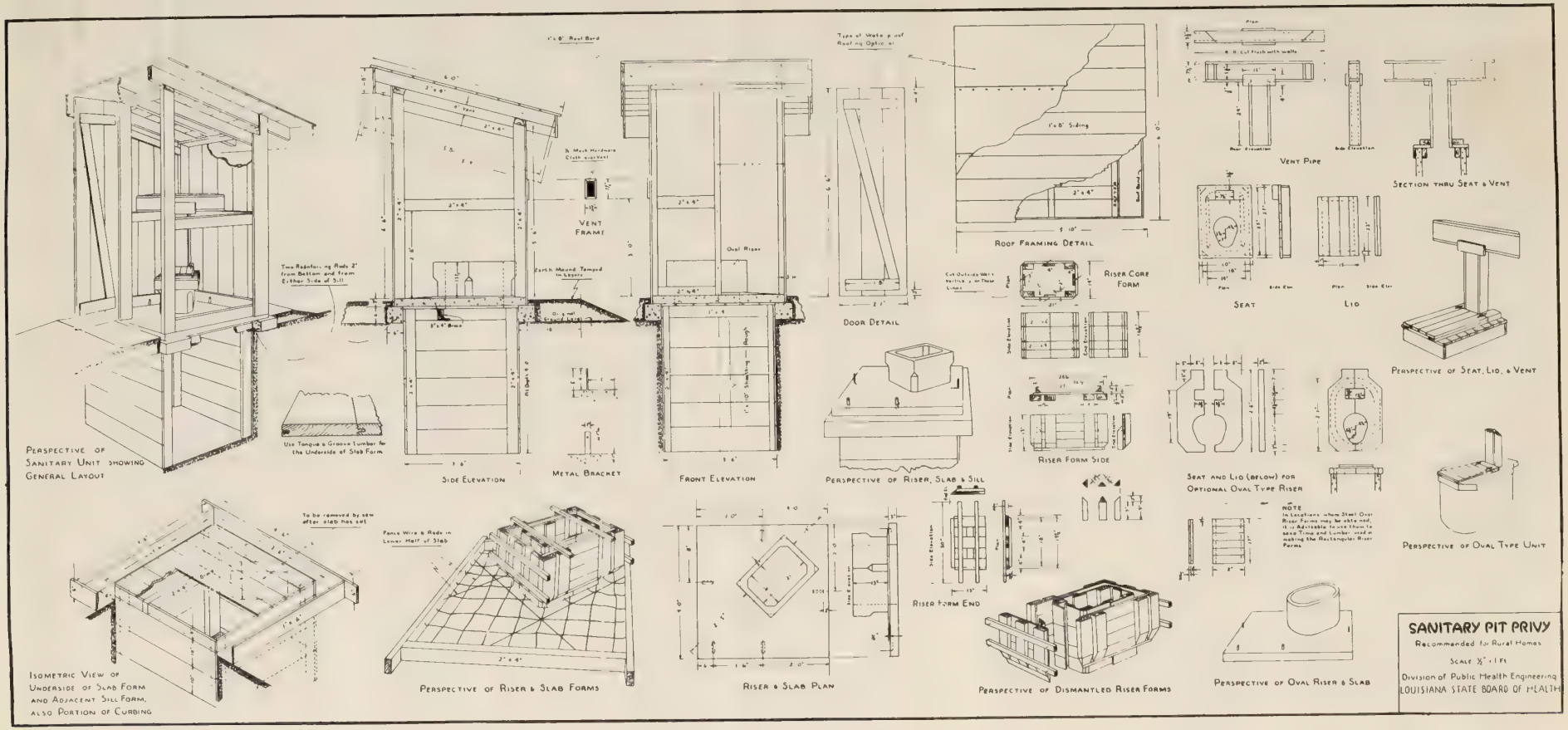

PERSPECTIVE OF SANITARY UNIT SHOWING GENERAL LAYOUT
SIDE ELEVATION
VENT FRAME
METAL BRACKET
FRONT ELEVATION
DOOR DETAIL
ROOF FRAMING DETAIL
RISER CORE FORM
RISER FORM SIDE
PERSPECTIVE OF RISER, SLAB & SILL
VENT PIPE
SECTION THRU SEAT & VENT
SEAT
LID
PERSPECTIVE OF SEAT, LID, & VENT
SEAT AND LID (BELOW) FOR OPTIONAL OVAL TYPE RISER
PERSPECTIVE OF OVAL TYPE UNIT
ISOMETRIC VIEW OF UNDERSIDE OF SLAB FORM AND ADJACENT SILL FORM, ALSO PORTION OF CURBING
PERSPECTIVE OF RISER & SLAB FORMS
RISER & SLAB PLAN
RISER FORM END
PERSPECTIVE OF DISMANTLED RISER FORMS
PERSPECTIVE OF OVAL RISER & SLAB
SANITARY PIT PRIVY
Recommended for Rural Homes
Scale ½" = 1 Ft.
Division of Public Health Engineering
LOUISIANA STATE BOARD OF HEALTH

Fig. 33 Standard Pit Privy

This plan is taken from the recommended plan by the U. S. Public Health Service, Reprint No. 2461, Public Health Reports, reprinted 1950.

vent from pit or riser may lead to a horizontal vent passing through both side walls or diagonally across a corner of the building. In all cases vents are screened. Galvanized steel wire screen dipped in paint, copper screens, and bronze screens are used. Nearly all designs employ a screen with 16 meshes to the inch. Hardware cloth is used to cover the outside entrance to vents to prevent entrance of large objects which would clog the vent.

It is stated by some authorities that venting serves no useful purpose and that vents should be eliminated from earth pit privies. The Joint Committee on Rural Sanitation believes that satisfactory recommendations with respect to vents can be made only after certain technical problems have been solved. The most important of these is the moisture condensation problem due to the temperature difference between the pit and the superstructure. The use of a cold wall to condense moisture within the pit has been suggested. In view of the uncertain value of venting, no recommendations are offered by the committee. Further research and study are indicated. Nevertheless, many health departments and the U.S. Public Health Service have included vents in their recommended plans for privy construction.

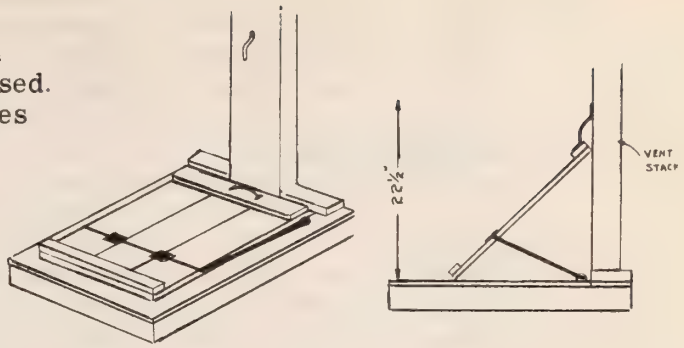


Fig. 34 Improved Self-Closing Seat Cover

This seat cover removes the incentive for fastening the lid open with hooks or other devices. It overcomes the two objections to the ordinary self-closing lid:
1. The contact between the soiled bottom surface of the lid and the user's clothing;
2. The discomfort to the user of having the lid rest on the upper surface of his back.

Superstructure. Privy structures are standardized to some extent. The majority are 4 by 4 feet in plan, with a height in front of 6 feet 6 inches and at the rear of 5 feet 6 inches. Roofs with a 1 to 4 slope are commonly used. Variations provide a floor plan 4 feet wide and 5 feet deep, and 5 feet wide and 4 feet deep. The building should be constructed of substantial material, painted for resistance to weather, and fastened solidly to the floor slab. Proper roof overhang should be provided to dispatch rain water from the roof away from the mound. The roof should be constructed of watertight materials. Wood, composition shingles, or metal are suitable. Ventilation of the building by omitting siding beneath the roof is common except in cold climates. Here the siding is usually perforated with holes. Windows are sometimes used in the northern latitudes. Provision of coat hooks is also desirable.

Material List for Earth Pit Privy

All Lumber Except Curb Sheathing to be Dressed

Curb:
- 2 Pcs. - 2" x 4" x 10'0" - Uprights
- 1 Pc. - 2" x 4" x 4'0" - Horizontal brace for underside of slab form
- 10 Pcs. - 1" x 10" x 8'0" - Rough lumber for curb sheathing
- 2 Pcs. - 1" x 4" x 8'0" - Inside form of sill
- 12 Pcs. - 1" x 4" x 8'0" - Tongue and groove lumber for underside of slab form

Sill Slab:
- 2 Pcs. - 1" x 6" x 12'0" - Outside form of sill
- 2 Pcs. - 2" x 4" x 10'0" - Outside form of slab

Riser Form:
- Rectangular:
- Inside Form (Riser Core)
- 1 Pc. - 2" x 4" x 6'0" - Corner Post
- 1 Pc. - 1" x 4" x 12'0" - Intermediate posts
- 1 Pc. - 1" x 6" x 12'0" - T & G for sides
- 1 Pc. - 1" x 4" x 12'0" - T & G for sides

Outside Form (Sides and Ends)

3 Pcs. - 1" x 4" x 12'0" - T & G for sides
1 Pc. - 2" x 4" x 10'0" - Corner Angles
1 Pc. - 2" x 4" x 6'0" - Cleats
1 Pc. - 1" x 4" x 10'0" - Rip to 1" x 2" for tie bars

Oval Type: (Optional)
A United States Public Health Service metal form may be used where obtainable.

Superstructure:

9 Pcs. - 2" x 4" x 10'0" - House Frame
11 Pcs. - 1" x 8" x 12'0" - Sides, back and door
1 Pc. - 1" x 8" x 14'0" - Door
1 Pc. - 1" x 10" x 8'0" - Door; remainder to be used for horizontal brace for door
1 Pc. - 1" x 4" x 6'0" - Diagonal brace for door

Roof:

3 Pcs. - 2" x 4" x 6'0" - Rafters
2 Pcs. - 1" x 8" x 12'0" - Roof band

Roofing (Optional):

A) Composition Roofing
5 Pcs. - 1" x 8" x 12'0" - Siding
1 Roll - Composition roll roofing - slate surfaced 90#/ square

B) Galvanized Iron Roofing
2 Pcs. - 1" x 4" x 12'0" - Strips
3 Pcs. - 2' x 6' Corrugated metal roofing

Seat and Lid (Optional)

A) With Rectangular Riser
4 Pcs. - 1" x 4" x 6'0" - T & G for Seat and Lid
2 Pcs. - 1" x 4" x 6'0" - Finished Seat Frame

B) With Oval Riser
1 Pc. - 2" x 10" x 5'0" - Seat
1 Pc. - 1" x 2" x 6'0" - Frame
1 Pc. -3/8" x 4" x 6'0" - Lid

T-Vent:

1 Pc. - 1" x 6" x 12'0" - Front and back
1 Pc. - 1" x 4" x 12'0" - Sides

Hardware:

1 Pair 6" strap hinges - Door
1 Pair 3" strap hinges - Seat
2 lbs. 16 penny nails
4 lbs. 8 penny nails
3 lbs. 6 penny nails
5 metal brackets
2 Pcs. 4" x 8" - 16 mesh copper screening
2 Pcs. 4" x 8" x 1/4" mesh galvanized hardware cloth

Slab and Sill:

1 Pc. - Hog Wire - 4' x 4'
3 Pcs. - 1/4" - 3'0" bars) Slab
1 Pc. - 1/4" - 2'0" bars)
2 Pcs. - 3/8" - 9'0" bars - Sill
2 Pcs. - 3/8" - 10'0" bars - Sill

2 bags Cement 4 Cu. ft. Sand 8 Cu. ft. Gravel	1:2:3 Mix, or 1:2:4 Mix

Construction of Sanitary Pit Privies

In accordance with the above description of the general structure of a sanitary pit privy, and the plan in **Fig. 33,** the steps to be taken in constructing a concrete sanitary pit privy are:

1) Dig the hole according to recommended measurements.

2) Construct the curb. If the concrete is to be poured in place, the box is constructed, open at the bottom and closed on top, with the undressed lumber for the sheathing, and 2" x 4" verticals at the corners. Make sure that the uppermost sheathing boards approximate tightly for several feet below the earth's surface. The top is made with tongue and groove lumber, and this will serve as the underside of the floor slab form. If the floor slab form is not to be poured in place, then the top and bottom of the box are left open.

3) If the concrete sill is to be poured in place, the 1" x 4" pieces of lumber are used to make the uppermost part of the box, and these extra 4 inches of the box above the curb sheathing should project above the ground level and serve as the inside form of the sill. A 2" x 4" is nailed inside the projecting part of the box as a brace for the top. Then the 1" x 6" pieces are made into a 4 1/2 foot square - inside measurements. This serves as the outside form of the sill. The sill is then poured. If one desires to anchor the housing to the concrete sill instead of to the floor slab, then bolts are set into the sill when it is poured. In this case a wooden sill made of 2" x 4" lumber is anchored to the concrete sill, and the superstructure is nailed to this wooden sill. Metal rods are used as reinforcement for the concrete sill. The sill may also be poured "out of place" in 4 sections or in one piece.

4) If the concrete floor slab and riser are to be poured in place, the box top and the concrete sill serve as the bottom of the form. The sides of this form are made of four pieces of 2" x 4" lumber which are nailed together forming a 4 foot square - inside measurement. If the slab is not to be poured in place, put the form on a clear, level ground surface covered with paper, allowing the covered ground to be the bottom of the form.

5) The 4' x 4' hog wire fencing or similar metal lathing is placed in the slab form parallel to and 6 inches from each side of the form. Several re-enforcing rods are placed on top of this wire as shown in **Fig. 33.** Before placing the hog wire, remember to cut a hole in it large enough to admit the riser form, and also to allow 4 or more inches of the wire to be turned up into riser form.

6) The riser form is then set in the hole cut for it. The riser form may be round and made of galvanized iron similar to the type loaned to the states by the U. S. Public Health Service or it may be square and made of wood. The riser is 13 inches high above the slab top. The riser walls are 2 inches thick.

7) The concrete is mixed, poured, and finished to a thickness of 3 to 3 1/2 inches at the riser and 2 1/2 to 3 inches at the edges of the slab. (See Chapter on Making Concrete.) Metal brackets or bolts are set into the concrete of the slab on each side to extend high enough for anchoring the wooden superstructure. If the seat be the type that is held in place by fitting snugly around the top rim of the riser, then it is not necessary to set bolts into the top of the riser. Otherwise, place several bolts, 1/4 x 6 inches, into the concrete to hold the seat and cover in place.

8) After the concrete is dried, drill several holes in the floor form inside the riser and cut out the wood so that the space in the riser and the space in the box become continuous.

9) If the floor slab be poured "out of place", several thicknesses of newspaper and a little cement grout are placed on the sill curbing before the slab is set.

10) The seat and cover are made. If one wishes, strips of old inner tube can be tacked to the underside of the seat and cover as gaskets in order to make tight joints.

11) If a ventilator is to be used, it is made usually to rise from the fixed portion of the seat. A ventilator may also be made with water vent piping 3 1/2 to 4 inches in diameter. The pipe is set into the concrete floor when it is poured.

12) The superstructure is constructed according to plan in Fig. 33.

13) Finally, the earth is banked up to and around the concrete sill and tamped solidly down to form a solid embankment around the privy for at least 18 inches. Beyond this the embankment is tapered gradually toward the ground level.

If the construction of a multiple-hole privy be desired, 2 additional feet of floor should be added for each added seat. Privies with more than 4 seats can be constructed, but it is not advisable to do so without consulting an engineer due to the stress problems involved.

Although the plan in Fig. 33 shows the riser in the back corner of the privy, some prefer to place it in the middle of the floor or approximating the back wall in order to make it easier to clean the floor.

In areas where the water-table may be expected to be high, it is wise to dig a test hole 6 to 12 inches square and 4 feet deep to note whether the water-table is too high to build a pit privy.

Masonry (or Concrete) Vault Privy (Fig. 35)

A masonry vault privy is essentially a pit privy in which the pit is lined with impervious material, and in which provision is made for the removal of excreta.

Masonry vaults find their use chiefly where the ground water table is close to the ground surface or where it is necessary to prevent contamination of nearby water courses, wells, and springs. They are also used to some extent in limestone formations to prevent contamination of the water streams which occur in the solution channels of the limestone. Another advantage, especially in cold weather regions, is that the seats usually are placed within the house or school.

The safety factors expected through the use of this type of privy are seldom achieved in actual practice. The leakage which generally occurs effects the safety features. Vaults are seldom built large enough and consequently frequent cleaning of vaults is necessary.

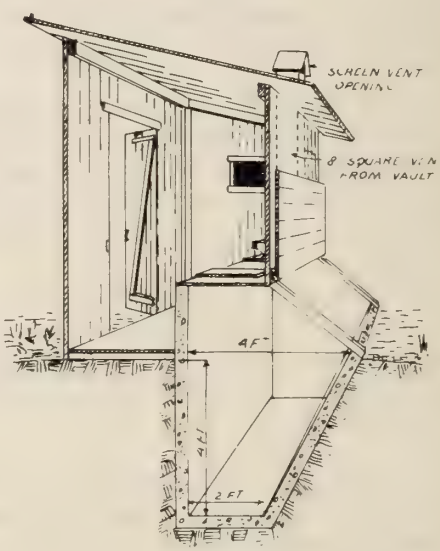


Fig. 35. Concrete Vault Privy

Masonry vaults may be constructed of brick, stone, or concrete, although the latter is preferred. Vaults must be watertight to keep out ground-water and prevent leakage of the vault contents. A readily accessible clean-out door is necessary. This door must be constructed to prevent access of flies, animals, and surface water to the vault contents, and is usually located in a (often slanting) section of the roof of the tank placed outside of the building. The floor of the superstructure which forms a partial covering for the vault must be impervious. Concrete is recommended.

Cleaning of vaults is usually done by scavengers who pump or dip the wastes from the vault. Even with careful manipulation, spillage occurs, especially about the clean-out door. Vault contents must be either buried or disposed of in a public sewer system. Again maintenance and supervision are large factors in the successful use of this type of disposal. The same type of superstructure, seat, riser, floor, and vent are used for masonry vault privy as for earth pit privy.

This type of disposal unit is satisfactory where it is essential that pollution of nearby water sources be prevented and where adequate maintenance and servicing are assured.

Chemical Toilet

There are generally two types of chemical toilets: (a) commode type in which a pail containing a chemical solution is placed immediately beneath the seat; (b) the tank type in which a metal tank which holds the chemical solution is placed in the ground directly beneath the seat. **(Fig. 36)** A pipe or conduit connects the riser with the tank. Tanks are usually cleaned by draining to a subsurface seepage pit. Chemical toilets differ from privies in that they are commonly placed inside the dwelling, whereas privies are generally located apart from the dwelling.

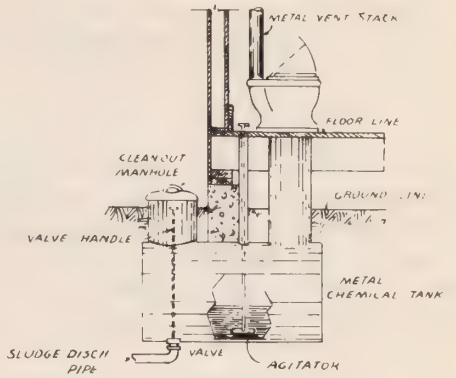


Fig. 36. Chemical Toilet

Toilets of this type are usually predominant in cold climates where it is found desirable to have toilet facilities in or near the home where running water is not available for flush toilets. The commode type is common in recreational areas, at individual homes, and where there is sickness or an invalid in the family

Sodium hydroxide is commonly used to prepare the caustic solution used in commode or tank types of chemical toilets. The chemical is dissolved in water and placed in the receptacle. The purpose of the chemical solution is to emulsify the fecal matter and paper and to liquify the contents. In order to accomplish this action, the chemical solution must be maintained at a proper strength and the mixture agitated each time the toilet is used. Odors are produced chiefly by the liberation of ammonia if the caustic solution be weak or if mixing by agitation be not carried out.

Difficulties are encountered when the caustic solution becomes diluted and fails to emulsify the fecal matter. The chemical solution breaks down due to absorption of carbon dioxide from the air and the solution ceases to be caustic. Decomposition of fecal matter takes place with foul odors emanating from the unit.

Disposal of the resultant mixture is a disagreeable task. In the case of small commode types the usual method of disposal is by burial in the earth, or using a pit privy wherever available. Tank units are usually so constructed that the tank is emptied into a seepage pit. When emulsification is not complete, particles of paper clog the seepage pit, thus requiring corrective measures. Because of fundamental differences in design, chemical toilets resemble other types of privies only in the seat construction and manner of venting. Usually risers or stools manufactured commercially are used.

Chemical toilets depend entirely on the caustic action of the chemical to prevent any biologic changes in the sewage and consequently they should be used only where there is assurance of constant maintenance and where safe disposal of the final product is assured. Neither sludge nor liquid effluent from chemical toilet tanks should be discharged to a sewerage system where treatment processes are involved. Otherwise, the chemical constituents of the sludge or liquid effluent may seriously interfere with the biological action upon which such treatment processes depend.

Pail or Can Type Privy

A pail or can type privy is one that employs the use of a watertight container directly beneath the seat for receiving deposits of human excreta.

This type of privy provides one means of disposal of body wastes under certain conditions. Temporary camps, such as Boy Scout camps, military camps, refugee camps, town subdivisions which could not immediately be connected to the city sewer system, etc., all of short duration, may well utilize such means of disposal provided the necessary scavenging system is available for regular maintenance.

It is essential that there be responsible supervision if this type of disposal is to be expected

to function properly. Provision must be made for daily removal of receptacles for cleaning. If scavenging service is to be satisfactory, soiled cans should be replaced by clean ones, preferably daily. The soiled cans should be hauled to a central point where facilities are provided for emptying and cleaning them. If a water supply line be used for can cleaning purposes, it should be equipped with an approved back flow prevention device. Facilities must be provided for final disposal of the excreta. The methods recommended in order of preference are: (a) Disposal into a public sewer system or sewage treatment plant; (b) disposal by burial in the ground with immediate covering of earth.

A new type of toilet, originally designed for trailers and airplanes is in use in portable housing developments such as house trailer camps where sewer systems have not been installed. This toilet provides a special roll of paper coated with asphaltum and by means of a rachet lever the wastes are folded and sealed in a paper tube or envelope. While this method removes some of the objectionable features of the pail and can type privy, the problem of final disposal of the waste remains. Daily removal of excreta is necessary and maintenance of the mechanism is a problem.

There are no pits in this type of privy. Floor, riser, seat, vent, and superstructure requirements are the same for this type of privy as for the earth pit privy.

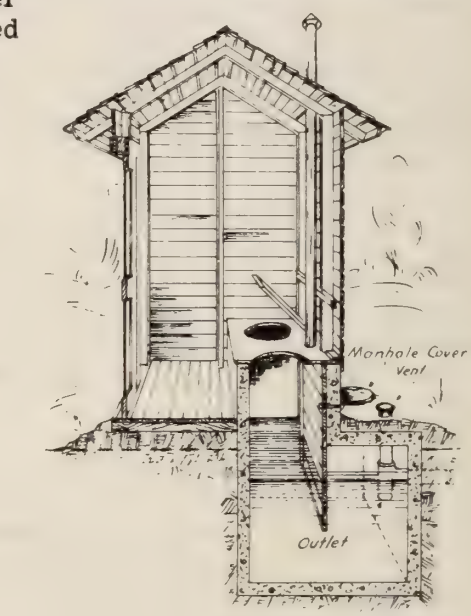
Since pail or can types of privies are limited in usefulness due to excessive maintenance factors they should be used only in camps of a temporary nature.

The Septic Privy

A septic privy is practically a septic tank partly located under the dwelling but lacking running water. Water must be added by hand. It is more expensive to construct than other types of privies and requires more care. (Fig. 37) Tanks are usually of concrete but some manufactured tanks are of metal. After the tank is once filled with water to overflow level, about two buckets of water must be added daily. For seven persons or less, a capacity of 200 gallons has been found sufficient. Ventilation should be provided and the vent pipe screened against flies. It is advisable to pour kerosene or other oil over the tank contents once a week to prevent mosquito breeding and keep down odors. The overflow from the tank is conveyed to a drain line or leaching pit. Cleaning out of solids might be necessary in one to five years.

Cremating Latrine or Incinerator Privy

A cremating latrine or incinerator privy is essentially a pit privy designed to permit destruction of the excreta by incineration. Auxiliary fuel is provided to aid destruction of the body wastes. These types of privies are not being advocated any more.



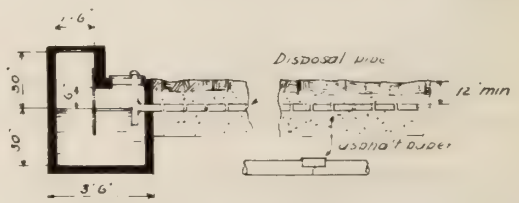


Fig. 37. Kentucky Septic Privy

Suggested Legislation* for Individual Sewage Disposal Systems
[Title should conform to State requirements]

(Be it enacted, etc.)

Section 1. Short Title. This Act shall be known and may be cited as the "(State) Individual Sewage Disposal Systems Act."

Section 2. Findings and Policy. (a) The (State) legislature finds that properly planned, constructed, and installed individual sewage disposal systems --

(1) promote the health and welfare of citizens of this State by preventing the pollution of ground and surface water;
(2) prevent nuisances;
(3) eliminate hazards to the public health by minimizing pollution of water supplies and hazards to recreational areas; and
(4) minimize disease transmission potential.

(b) It is, therefore, declared to be the public policy of this State to eliminate and prevent health and safety hazards by regulating the design, construction, installation, operation, and maintenance of individual sewage disposal systems and the proper planning thereof; authorizing the issuance of permits for the construction, alteration, repair or extension of individual sewage disposal systems; licensing of installers of individual sewage disposal systems; requiring registration of those who clean systems and dispose of wastes therefrom; and, providing penalties for violations.

Section 3. Definitions. As used in this Act:
(a) "Community sewerage system" means any system, whether publicly or privately owned, serving two or more individual lots, for the collection and disposal of sewage or industrial wastes of a liquid nature, including various devices for the treatment of such sewage or industrial wastes.

(b) "Department" means the designated agency presently having authority to regulate sanitary practices within the State, usually the State Department of Health.

(c) "Industrial wastes" means liquid wastes resulting from the processes employed in industrial and commercial establishments.

(d) "Individual sewage disposal system" means a single system of sewage treatment tanks and disposal facilities serving only a single lot.

(e) "Municipality" means a city, town, borough, county, parish, district, or other public body created by or pursuant to State law, or any combination thereof, acting cooperatively or jointly.

(f) "Person" means any institution, public or private corporation, individual, partnership, or other entity.

(g) "Potable water" means water free from impurities in amounts sufficient to cause disease or harmful physiological effects with the bacteriological and chemical quality conforming to applicable standards of the Department. [1]

1. In the absence of available State standards, Public Health Service Drinking Water Standards, (PHS Pub. No. 956), should apply.
* Recommended State Legislation and Regulations, Department of H. E. W., Public Health Service, July 1965.

(h) "Seepage pit" means a covered pit with open-jointed lining through which septic tank effluent may seep or leach into surrounding ground.

(i) "Septic tank" means a watertight receptacle which receives the discharge of a building sanitary drainage system or part thereof, exclusive of industrial wastes, and is designed and constructed so as to separate solids from the liquid, digest organic matter through a period of detention, and allow the liquids to discharge into the soil outside of the tank through a system of open joint or perforated piping, or a seepage pit.

Section 4. Scope. No person shall construct, alter, repair, or extend, or cause to be constructed, altered, repaired, or extended any individual sewage disposal system contrary to the provisions of this Act and applicable rules and regulations.

Section 5. Authority to Adopt Rules, Regulations, and Procedures. The Department shall have general supervision and authority over the design, construction, installation, and operation of individual sewage disposal systems, and shall be responsible for the administration of this Act. With respect thereto it shall --

(a) adopt, and from time to time amend, rules and regulations governing the design, construction, installation, and operation of individual sewage disposal systems in order that the wastes from such systems --

(1) will not pollute any potable water supply, or the waters of any bathing beach, shellfish growing area,[2] or stream used for public or domestic water-supply purposes, or for recreational purposes;
(2) will not give rise to a public health hazard by being accessible to insects, rodents, or other possible carriers which may come into contact with food or potable water, or by being accessible to human beings; and
(3) will not give rise to a nuisance due to odor or unsightly appearance.

(b) hold public hearings, upon not less than sixty (60) days' prior notice published in one or more newspapers, as may be necessary to assure general circulation throughout the State, in connection with proposed rules and regulations and amendments thereto;[3]

(c) enforce the provisions of this Act and any rules and regulations adopted pursuant thereto;

(d) delegate, at its discretion, to any municipality any of its authority under this Act in the administration of the rules and regulations adopted hereunder;

(e) issue permits, licenses, registration, and other documents, including the establishment of procedures and forms for the submission, review, approval, and rejection of applications required under this Act; and

(f) issue such additional regulations, and take such other actions as may be necessary to carry out the provisions of this Act.

Section 6. Existing Installations. No individual sewage disposal system in existence on the effective date of this Act shall be required to conform to the design, construction, and installation provisions of this Act, or any rules or regulations adopted pursuant thereto; provided, however, that any individual sewage disposal system being used which is determined by the Department to be a health hazard must conform with the provisions of this Act and applicable rules and regulations within a reasonable time after notification of such determination has been given.

2. Optional with locality.
3. This requirement should be consistent with the general practice for publication requirements in the State and with any State administrative procedure act which may apply.

Section 7. Inspections. (a) The municipality is hereby authorized and directed to make inspections of individual sewage disposal systems as may be necessary to determine substantial compliance with this Act and regulations adopted hereunder, and such systems shall not be used unless approved by the municipality. Upon the basis of such inspections, the Department shall either approve or disapprove the individual sewage disposal system, and if disapproved the system shall not be used.

(b) It shall be the duty of the holder of a permit issued pursuant to Section 8 of this Act to notify the municipality when the installation is ready for inspection and it shall be the duty of the owner and occupant of the property to give the municipality free access to the property at reasonable times for the purpose of making such inspections as are necessary.

(c) In the event an inspection be not made upon notification of the muncipality that the installation is completed and ready for inspection, the system shall be deemed approved after _____ days[4] from date of official notification.

(d) Any person aggrieved by the disapproval of an individual sewage disposal system installation shall be afforded the opportunity of a hearing as provided in Section 13 of this Act.

Section 8. Permits. (a) It shall be unlawful for any person to construct, alter, repair, or extend individual sewage disposal systems unless he holds a valid permit[5] issued by the municipality in the name of such person for the specific construction, alteration, repair, or extension proposed, except that emergency repairs may be undertaken without prior issuance of a permit, provided a permit be subsequently obtained within _____ days after the repairs are made.

(b) Permits shall be issued only to licensed installers as provided in Section 9 of this Act, or to an owner or lessee of a lot on the condition that the said owner or lessee performs all labor in connection with the installation of the individual sewage disposal system on such lot.

(c) All applications for permits shall be made on a form which includes such information as may be required by the municipality to establish conformance with the provisions of this Act and any regulations adopted hereunder.

(d) Following determination of conformance with the requirements of this Act and regulations issued pursuant thereto, the municipality to which application has been made shall issue a permit to the applicant.

(e) A permit for the construction, alteration, repair, or extension of an individual sewage disposal system shall be refused where community sewerage systems are reasonably available or in instances where the issuance of such permit is in conflict with other applicable laws and regulations.

(f) Any person whose application for a permit under this Act has been denied, shall be notified in writing as to the reasons for denial, and such person may request, and shall be granted a hearing on the matter in accordance with Section 13 of this Act.

Section 9. Licensing of Installers.[6] (a) Every person engaged in the business of installing individual sewage disposal systems within the State shall obtain from the Department a license to conduct such business.

4. Three (3) days are suggested to prevent damage to an open system.
5. The permit issued by the municipality is in addition to the building permit usually required and would be obtained prior to construction, alteration, repair, and extension of the residence or facility to be served.
6. Optional provision.

(b) The Department may adopt, and from time to time amend rules and regulations establishing qualifications and minimum standards of experience and knowledge for installers. The Department shall license as an installer any person properly making application therefor, who is not less than twenty-one (21) years of age, has knowledge of rules and regulations adopted under this Act, and has had not less than two (2) years' experience in installing individual sewage disposal systems.

(c) An application for a license as an installer shall be made in writing in a form prescribed by the Department, and shall include such information as the Department deems necessary to determine the qualifications of the applicant.

(d) Any person whose application for a license under this Section has been denied shall be notified in writing as to the reasons for denial, and such person may request, and shall be granted, a hearing on the matter in accordance with Section 13 of this Act.

(e) Whenever the Department determines that the holder of any license issued pursuant to this Section has violated any provision of this Act, or any rule or regulation adopted pursuant thereto, the Department is authorized to suspend or revoke any such license. Any Order issued pursuant to this Subsection shall be served upon the license holder pursuant to the provisions of Section 12 of this Act. Any such Order shall become effective _____ days after service thereof, unless a written petition requesting hearing, under the procedure provided in Section 13, be filed sooner. Any person aggrieved by any Order issued after such hearing may appeal therefrom in any court of competent jurisdiction as provided by the laws of this State.

(f) No application for a license issued pursuant to this Section may be made within one (1) year after revocation thereof.

Section 10. Required Registration for Cleaning Systems and Disposal of Wastes.

(a) The provisions of this Section shall not apply to any municipality, sanitation district, or sewer maintenance district, or to any agency or institution of the State or Federal Government.

(b) It shall be unlawful for any person to carry on, or engage in the business of cleaning individual sewage disposal systems, or to dispose of the wastes therefrom unless duly registered by the Department for the carrying on of said business.

(c) All applications for registration under this Section shall be made in writing in a form prescribed by the Department, and shall include such information as the Department deems necessary to determine the qualification of the applicant, including a knowledge of the regulations.

(d) Any person whose application for registration under this Section has been denied shall be notified in writing as to the reasons for denial, and such person may request, and shall be granted, a hearing on the matter in accordance with Section 13 of this Act.

(e) Whenever the Department determines that the holder of any registration issued pursuant to this Section has violated any provision of this Act, or any rule or regulation adopted pursuant thereto, the Department is authorized to suspend or revoke any such registration. Any Order issued pursuant to this Subsection shall be served upon the registration holder pursuant to the provisions of Section 12 of this Act. Any such Order shall become effective _____ days after service thereof, unless a written petition requesting hearing, under the procedure provided in Section 13, be filed sooner. Any person aggrieved by any Order issued after such hearing may appeal therefrom in any court of competent jurisdiction as provided by the laws of this State.

(f) No application for a registration issued pursuant to this Section may be made within one (1) year after revocation thereof.

Section 11. Schedule of Fees. The following fees for permits, licenses, and registration are required:

	Fee
Individual Sewage Disposal System	
Construction (permit)	---
Alteration (permit)	---
Repair (permit)	---
Extension (permit)	---
Installers (license)	---
Cleaners (registration)	---

Section 12. Enforcement. (a) Whenever the Department has reasonable grounds for believing that there has been a violation of this Act, or any rule or regulation adopted pursuant thereto, the Department shall give written notice to the person or persons alleged to be in violation. Such Notice shall identify the provision of this Act, or regulation issued hereunder, alleged to be violated and the facts alleged to constitute such violation.

(b) Such Notice shall be served in the manner required by law for the service of process upon person in a civil action, and may be accompanied by an Order of the Department requiring remedial action, which if taken within the time specified in such Order, will effect compliance with the requirements of this Act and regulations issued hereunder. Such Order shall become final unless a request for hearing as provided in Section 13 of this Act be made within _____ days from the date of service of such Order. In lieu of such Order, the Department may require the person or persons named in such Notice to appear at a hearing, at a time and place specified in the Notice.

Section 13. Hearing.
[Unless already prescribed in State law, this Section should be used to specify procedures for administrative hearing.]

Section 14. Judicial Review.
[Unless already prescribed in State law, this Section should be used to specify procedures for judicial review.]

Section 15. Penalties. (a) Any person who fails to comply with any provision of this Act, or regulations issued hereunder, or Order pursuant hereto, shall be subject to a penalty of $_____. Every day, or any part thereof, in which such violation occurs shall constitute a separate violation.

(b) The Department is authorized to require the property owner to take necessary action to correct a malfunctioning individual sewage disposal system within _____ days of being notified[7] after which, each day's failure to take corrective action shall be punishable by a fine of not less than $_____ nor more than $_____.

Section 16. Conflict with Other Laws. The provisions of any law or regulation of any municipality establishing standards affording greater protection to the public health or safety shall prevail within the jurisdiction of such municipality over the provisions of this Act and regulations adopted hereunder.

Section 17. Severability. [Insert severability clause.]

Section 18. Effective Date. [Insert effective date.]

7. In accordance with applicable State procedural requirements.

Chapter XVI

Quality of Milk

The milk is the first food of human life. It is the most nutritious food known, but also one of the most quickly perishable foods resulting from bacterial action. Although in the years from 1938-50 inclusive, there were 448 water-borne epidemics in the United States with 131,823 cases of disease reported and 401 milk and milk products-borne epidemics reported with only 16,232 cases of disease, there were, nevertheless, only 94 deaths reported among former cases as compared to 103 deaths among the latter cases. At that time, therefore, it appeared that milk-borne diseases in the United States had an 8 times greater force of death than those which were water-borne. However, in the years 1961-66, there were only 19 milk-borne outbreaks reported with 623 cases and no apparent deaths. Sanitation in milk production and distribution has certainly reduced the actual hazard, but the potential hazard remains the same. Incidental to the disease hazards of contaminated milk are the economic losses resulting from bacterial spoilage of milk. Such spoilage is responsible for the waste of many tens of thousands of gallons of milk annually. The sanitarian, therefore has a special interest in the bacteriology of milk because it is his particular function to watch over the sanitary aspects of the production and distribution of milk and milk products. He must understand the dynamics by which milk becomes the vehicle of disease germs and other bacteria responsible for milk spoilage. He must understand the techniques of detecting the danger signs of milk contamination. And, as a result of this understanding, he will be enabled to teach and enforce hygienic methods for sanitary control of milk production and distribution. The sanitarian can be proud of the great number of lives that have been saved in the United States by the sanitary protection of the milk supply.

Sources of Bacteria in Milk

The common bacteria of market milk are Streptococcus lactis, Streptococcus cremoris, Escherichia and Aerobacter, Staphylococcus, Micrococcus, Actinomyces, Lactobacillus, Sporeformers, yeasts and molds. Even when drawn with aseptic precautions, milk always contains a certain number of bacteria which are derived from the milk ducts of the cow's udder. Their numbers vary considerably from quarter to quarter of udders and from cow to cow, and are highest in the fore-milk and lowest in the strippings. The average plate count of aseptically drawn milk has been given by different workers as less than 10 per cubic centimeter to several thousand. Many of the lower counts have probably underestimated the true number owing to unsuitable technique in counting, while many of the higher counts have probably been made on milk derived from udders that were not strictly normal. Considering the extraordinary frequency of mastitis, (50% of the animals in a herd often show disease of one or more quarters), it is very difficult to arrive at any definite conclusion on the probable numbers of bacteria in milk coming from healthy udders. If the udder be diseased, Streptococci, Brucella abortus, tubercle bacilli, and other organisms may be excreted in the milk in large numbers —sometimes running into several thousands per c.c.

When aseptic precautions are not employed, the milk is liable to be contaminated with bacteria from the outside of the udder, the interior of milk vessels and utensils, and dust in the atmosphere of the milking shed. Of these various sources, far the most important is unsterilized milking equipment. The total number of organisms gaining access from the air and from dust is almost negligible compared with that derived from the surfaces of unsterilized pails, coolers, cans, strainers and bottle fillers. Unless these utensils be actually sterilized, their surfaces become coated with bacteria of various types which may contribute enormous numbers of microorganisms to the milk.

An additional source of contamination is the human personnel. If wet milking be practiced, considerable numbers of organisms are liable to get washed into the milk from the milker's hands and from the exterior of the udder and teats unless these be thoroughly cleansed. Though numerically few, the organisms reaching the milk in this way may be of considerable public health importance, particularly if the milker happens to be a carrier of typhoid, paratyphoid, dysentery, or if the hands happen to bear an infection. The milker constitutes a further source of danger if he carries haemolytic streptococci or diphtheria bacilli in his throat or nose, since these organisms may gain access to the milk by way of the cough or sneeze spray.

Apart from initial contamination of the milk, imperfect cooling is often responsible for the presence of large numbers of bacteria in any given sample. However carefully milk is produced, sooner or later, provided it be kept at a suitable temperature, it will go sour or putrid as a

result of bacterial multiplication. If it is to remain sweet for more than a few hours, all milk should be cooled immediately after production to a temperature of 10°C. (50°F.) or below.

It may be noted that the keeping quality of the milk is determined partly by the degree of initial contamination and partly by the temperature at which it is kept. Milk produced under really clean conditions has a considerable bacteriostatic (prevents bacterial growth) power, and shows little bacterial multiplication for several hours, even when kept at a relatively warm temperature. On the other hand, the bacteriostatic effect in milk produced under dirty conditions is very slight, and bacterial multiplication sets in rapidly. For this reason it is much easier to distinguish between a milk produced under sanitary and one produced under unsanitary conditions if the examination be delayed till the milks have remained at a temperature around 60°F. for 12-18 hours. After such period milk produced under clean conditions will still have a relatively low bacterial count while milk produced under dirty conditions will contain a large bacterial population.

The production of clean milk is largely a matter of technique, not of structural equipment or refinement. Provided all utensils be sterilized and the surfaces of the udders and milker's hands be cleansed, it is not possible to produce milk with a very low bacterial content. It is, however, not easy to maintain a satisfactory technique day in and day out unless suitable conditions and appliances be provided for the workers.

Types of Bacteria in Milk

The bacteria present in milk from healthy cows may be classified into the following groups:

Acid-forming Bacteria. These organisms ferment the lactose in the milk resulting in production of acid, mainly lactic acid, which combines with the protein, calcium caseinogenate, liberating the free protein, casein; this, being insoluble in water, is precipitated in the form of a smooth, gelatinous curd. Streptococcus lactis is one of the most important species which causes souring. Certain Staphylococci which are not infrequently found in the udder are also active members of this group. We also include in this group the Lactobacilli such as L. thermophilus, L. caucasicus, L. acidophilus, and L. bulgaricus which are found in milk as frequently as Streptococcus lactis and can endure high degrees of acidity (thus describing them as aciduric or acidophilic). L. enzymothermophilus is capable of producing heat-stable phosphatase enzyme which can produce a false positive phosphatase test.

Gas-forming Bacteria. These organisms ferment lactose, producing both acid and gas. They produce a smooth gelatinous curd which is often riddled with gas bubbles. The acid produced is largely acetic which imparts an unpleasant flavor to the milk. Coliform bacilli are among the commonest representatives of this group and are practically always found in market milk.

Proteolytic (protein breaking) Bacteria. These organisms secrete one or the other, or both of two ferments —rennet and casease. Rennet acts in two stages; in the first stage it converts the protein compound, calcium caseinogenate, into a soluble form of casein; in the second stage the protein is converted into an insoluble form and is precipitated out. The resulting gelatinous clot gradually contracts and squeezes out the more or less clear fluid, which is known as whey; the whey contains the sugar, salts, and other proteins —lactalbumin and lactoglobulin —of the milk. Casease is a proteolytic enzyme which digests the proteins present in the milk, breaking them down to more elementary forms (proteoses, peptones, and amino acids).

When the rennet predominates, a firm white curd is produced which is slowly digested by the casease. When the casease is in excess, either no coagulation at all may occur, or a soft flocculent clot is formed which is rapidly broken down. The common proteolytic bacteria found in milk are the spore-forming Bacillus subtilis and Streptococcus liquefaciens. Some others are the spore-forming Proteus vulgaris, Bacillus mesentericus, and various Staphylococci and Micrococci. Some of the organisms in this group also ferment lactose so that the milk is rendered acid besides being clotted and digested.

Alkali-forming Bacteria. These organisms render the milk alkaline, presumably by acting on the proteins. Some of them also secrete lipase (enzyme which aids in breaking down of fat), and the combined effect (alkali, fat, and lipase) is to saponify (make into soap) the fat, and convert the milk into a yellow translucent whey-like fluid. This action is not often seen since the

members of this group of bacteria are overgrown by members of other groups which produce acid, coagulation, and peptonization (breaking down of proteins to peptones). Bacterium alkaligenes and some of the aerobic spore-bearers belong to this group.

Lipolytic (fat breaking) Bacteria. Various organisms hydrolyze fat causing the liberation of fatty acids and glycerol. (Hydrolysis is a chemical process whereby a compound is resolved into two other compounds by reacting with water.) The lower fatty acids found in milk fat, especially butyric and caproic acids, have conspicuously objectionable odors. When hydrolysis produces these acids the condition is commonly referred to as rancidity. Common lipolytic bacteria are Pseudomonas fragi, Achromobacter lipolyticum and Pseudomonas fluorescens. Many of the lipolytic organisms are also proteolytic.

Inert Bacteria. Many bacteria produce no visible change in milk and are hence called inert. Some of the udder cocci are included in this group. Members of the Achromobacterium group, most of which are probably derived from water are also relatively inert. It may be noted that most of the pathogenic organisms which may be present in milk belong to this group.

The pasteurization of milk and the development of finer techniques for approximating the quantity of bacteria in milk has led to a classification of several types of bacteria according to their temperature reactions.

a) Thermophiles - These are a group which are found to grow and reproduce in relatively high temperatures (around 60°C.) Whereas their growth and reproduction are suppressed as the temperature becomes lower. Most thermophiles are spore-forming aerobes. Some anaerobes are found among them. As far as is known, thermophiles are not pathogenic for man. Among the non-spore-formers are Lactobacillus thermophilus, Streptococcus thermophilus, and Bacillus calidolactis. At normal body temperature or at average weather temperatures they survive but do not readily reproduce. Because of this characteristic it has been found that some milk may show a higher bacterial count after pasteurization than before. Since such bacteria may enter milk thru unsanitary handling, it becomes necessary for milk produced for pasteurization to be handled in a most sanitary manner even though these thermophiles be not pathgenic. They may be numerous enough in pasteurized milk to decrease its keeping quality. These bacteria may also accumulate in the niches of a pasteurization unit, and if the unit be not regularly cleaned and sterilized the pasteurized milk may regularly show higher bacterial counts than expected.

b) Thermodurics - Recently the short-time-high-temperature method of pasteurization (i.e., holding milk at 71°C. for at least 15 seconds) became very popular because it prevented the growth and reproduction of thermophiles. But soon it was found that a certain type of bacteria which grows and reproduces at cooler or medium temperatures such as Bacillus subtilis, Streptococcus durans, and Streptococcus zymogenes, can survive the short-time-high-temperature method of pasteurization and may even survive if held over 30 minutes at high temperatures. These bacteria do not reproduce at such high temperatures. They are called thermodurics. They occur in a number of natural habitats, such as the soil and dust, feed grain and bedding, saliva and excreta of cows, on or in the skin of vertebrates including the udder and its milk, water from various sources and manure. Contaminated equipment and utensils are the important source of contamination. The fact that homogenization breaks up clumps of bacteria and may increase thermoduric counts may be a misleading indication of contamination in the milk plant. When plate counts of pasteurized milk become excessive for thermodurics, but the pasteurization process is adequate, a milk plant flow study should be made by the sanitarian. This is done by having plate counts made from the various batches of milk before and after pasteurization and also from the composite of all batches before heating, then from the preheating vat (noting the time interval of preheating,) then from below the cooler, and then from the final container. Finally he examines the study chart for an indication where the increase is likely to be. If the thermoduric contamination be suspected on a dairy farm, he follows a routine inspection course in the following sequence: Milk cans, utensils other than milking machines, milking machines, milking conditions, cooling and washing operations.

Lately, new techniques in making bacterial counts (by lowering the incubation temperature to 32°C - 35°C. and enriching the media) have revealed that these thermodurics which did not grow so well under the old methods, grow and develop very well by the new techniques. Thus, the

bacterial count by the new methods shows a much greater bacterial contamination of milk than by the old methods. This has created a number of complications. First of all, previously adequate milk may show up as inadequate due to the increased count; the dairies are thus put under a greater strain to keep within the upper limit of grade A range for bacteria. Secondly, it becomes apparent that the question must be settled as to whether the present bacterial ranges for Grade A milk may not be too low and therefore need revision. These problems must soon be settled.

c) Mesophiles are the bacteria which are the most common in milk and which grow and reproduce best at temperatures ranging between 21°C. and 38°C. This group includes the pathogens.

d) Psychrophiles are bacteria which grow and reproduce best at lower than body temperature. Some of this group will grow at temperatures close to freezing. Pseudomonas fragi which causes rancidity in butter is psychrophilic.

Pathogenic Microorganisms in Milk.

Apart from the organisms above described as being usually present in milk, there are others which sometimes are found in diseased tissues of the cow, or which gain access to the milk from a contaminated water supply or from some person handling the milk.

Mycobacterium tuberculosis. The presence of these organisms in milk depends on the frequency of bovine tuberculosis. The amount of tuberculosis among cattle in Europe was much greater than in the United States before the late war. It has been variously estimated that about 3% of cases of mastitis are caused by the tubercle bacilli. Before the war, positive tuberculin reactions were found in 30% of the cattle in Great Britain, 25% in Germany, and 40% in Holland. In the United States in 1910, 1918, and 1936, 9%, 5%, 0.5% of cattle showed positive tuberculin reactions.

Many cows which apparently look normal excrete tubercle bacilli in milk. Though definite disease of the udder cannot always be demonstrated clinically in these cows, they generally show tuberculous mastitis on microscopic examination. The more that milk is pooled, the more one can expect to find tubercle bacilli in samples of raw market milk. Butter may keep living tubercle bacilli over a period of many months. This bacillus may be excreted in the feces, and may live for three to five months in the pastures. Bovine tuberculosis can be transmitted to humans through milk and meat. Pasteurization destroys this organism.

Rabies virus has been found in the milk of infected animals. It is generally conceded that there is no danger from the ingestion of infected milk unless there be abrasions on the lips or along the alimentary tract. Rarely have cases of rabies in suckling infants or puppies been reported as developing from rabid females. Pasteurization destroys the virus and so does the ultra violet rays of the sun.

Bacillus botulinus. This is the cause of botulism, a type of food poisoning. Several outbreaks of this disease have been recorded due to contaminated cheese and canned milk. Pasteurization does not destroy this organism nor its toxin.

Foot-and-Mouth disease virus appears to be transmissible through milk from infected cattle. Several epidemics in humans appear to have been caused this way. Pasteurization of milk kills the virus.

Bacillus anthracis. This organism may be found in the milk of an infected cow. But milk is rarely responsible for human anthrax infection, since infected cattle are usually too ill to give milk. Pasteurization does not destroy this organism.

Poliomyelitis virus. At least three outbreaks of poliomyelitis have been reported in which it seems probable that raw milk served as the transmitting vehicle. Pasteurization destroys the virus.

Milk sickness. This is not caused by a germ but by a poison in the milk resulting from the consumption by the cow of white snake root or rayless goldenrod weeds. The offending poison is "tremetal."

Brucella abortus. This organism is responsible for infectious abortion of cattle and is even more prevalent than tuberculosis. The udder is frequently infected even in animals that have not aborted, though no lesions may be detected by clinical examination. The bacilli are excreted regularly or intermittently in the milk. Their numbers are usually greatest at the beginning of lactation, but in the later stages they may diminish greatly. The udder may remain infected for years. A high percentage of raw milk offered for human consumption appears to contain this organism. The disease in cattle is known as Bang's disease. When humans are infected, it is known as brucellosis or undulant fever. Pasteurization destroys this organism.

Streptococci. Mastitis producing streptococci are of various types. The most common being Strept. agalactiae which is of bovine origin and ordinarily not pathogenic for man. They are excreted in variable numbers in the milk of cows suffering from mastitis. This disease is extremely common, effecting not only the poorer herds, but even herds producing high-grade milk. The majority of streptococci causing mastitis in cows are probably non-pathogenic for man, but occasionally a strain pathogenic for man invades the udder and may be responsible for outbreaks of scarlet fever or septic sore throat in persons consuming the milk. The milk may also be contaminated directly with these organisms from persons suffering from streptococcal sore throat or hand lesions, or from carriers of these organisms. The important species pathogenic for man found sometimes in milk are Streptococcus pyogenes and varieties of this species such as Streptococcus hemolyticus, Streptococcus epidemicus and Streptococcus scarlatinae. Pasteurization destroys these pathogens.

Staphylococcus aureus. This organism is not an infrequent cause of mastitis. Almost 15% of cases of mastitis are due to Staphylococcus. It is sometimes found in an apparently healthy udder. But in cows suffering from acute mastitis, it may be present in large numbers in the milk. Its public health importance lies in the fact that under favorable conditions it may multiply in the milk and give rise to a toxin (poison) capable of producing food poisoning in humans. Pasteurization destroys these pathogens but not their toxins.

Table 1. Summary of Milk-Borne Disease Outbreaks Reported by State and Local Health Authorities as Having Occurred in the United States During the Years 1923-1966, Inclusive

	Typhoid			Paratyphoid			Scarlet Fever and Septic Sore Throat			Diphtheria			Dysentery			Food Infection, Food Poisoning and Gastro-enteritis			Undulant Fever			Miscellaneous			Total - All Diseases		
Year	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths
1923	15	423	31	[illegible]	0	0	7	406	[illegible]	1	[illegible]	0	0	0	0	[illegible]	0	0	0	0	0	0	0	0	23	834	37
1924	25	693	48	10	372	16	6	354	0	1	23	0	2	110	1	[illegible]	[illegible]	0	0	0	0	0	0	0	44	1,552	65
1925	31	580	43	2	37	4	10	1,108	8	1	14	1	[illegible]	0	0	0	[illegible]	0	0	0	0	0	0	0	44	1,739	56
1926	49	1,189	83	2	19	1	11	1,789	10	2	24	0	0	0	0	1	150	0	0	0	0	3	192	1	68	3,363	95
1927	24	430	35	2	53	[illegible]	4	389	5	2	15	0	0	0	0	1	50	0	[illegible]	17	1	0	0	0	36	954	41
1928	25	421	48	0	0	0	11	1,449	55	2	48	0	1	126	17	[illegible]	104	0	5	21	0	0	0	0	46	2,169	120
1929	29	541	36	1	38	1	19	1,891	14	0	0	0	1	8	0	1	24	0	0	0	0	0	0	0	51	2,502	51
1930	30	575	41	0	0	[illegible]	11	1,158	7	0	0	0	1	64	2	6	171	[illegible]	0	0	0	0	0	0	48	1,968	56
1931	21	217	16	1	22	0	[illegible]	1,059	8	1	22	0	1	65	0	1	13	0	0	0	0	0	0	0	34	1,398	24
1932	23	254	22	0	0	0	[illegible]	356	6	0	[illegible]	0	0	[illegible]	0	1	32	[illegible]	0	0	0	[illegible]	0	0	33	642	28
1933	25	299	26	1	17	0	10	753	9	2	19	3	0	0	0	[illegible]	[illegible]	0	0	0	0	4	260	1	42	1,348	39
1934	26	345	27	1	400	0	9	478	8	1	9	0	[illegible]	0	0	[illegible]	292	0	0	[illegible]	0	0	0	0	42	1,524	35
1935	16	172	14	2	50	0	11	1,065	7	0	0	0	1	131	0	13	411	0	0	0	[illegible]	0	0	0	43	1,829	21
1936	15	114	5	1	21	[illegible]	18	1,553	23	0	[illegible]	[illegible]	0	0	0	4	188	[illegible]	4	15	0	0	0	0	42	1,891	[illegible]
1937	15	208	11	0	0	[illegible]	14	1,384	3	0	0	0	0	0	0	12	523	0	[illegible]	[illegible]	0	2	35	0	43	2,150	14
1938	18	187	17	[illegible]	0	0	12	674	7	1	31	3	[illegible]	166	[illegible]	[illegible]	627	0	0	0	0	0	0	0	42	1,685	27
1939	6	51	1	2	24	0	[illegible]	1,324	6	0	0	0	2	324	0	19	749	0	1	4	0	2	33	0	41	2,509	7
1940	14	120	10	0	0	0	5	482	0	0	0	[illegible]	2	197	0	17	855	0	4	19	0	1	5	0	43	1,678	10
1941	12	120	4	0	0	0	3	219	[illegible]	1	5	0	3	126	0	15	483	0	3	96	[illegible]	0	[illegible]	0	37	1,049	[illegible]
1942	5	42	0	1	4	[illegible]	7	620	0	1	36	0	1	40	0	23	1,341	2	5	42	0	2	68	0	45	2,193	[illegible]
1943	6	37	1	[illegible]	0	[illegible]	3	200	0	1	20	4	0	0	0	25	1,278	0	4	22	2	1	33	0	40	1,590	7
1944	[illegible]	359	18	1	[illegible]	0	2	171	0	[illegible]	0	[illegible]	2	34	0	23	816	0	3	20	0	2	43	2	41	1,449	20
1945	3	72	4	0	0	0	3	308	0	1	53	[illegible]	1	22	0	18	1,673	11	[illegible]	19	0	1	14	0	29	2,161	17
1946	1	7	0	0	0	0	0	0	0	0	0	0	1	15	[illegible]	11	696	0	5	66	0	[illegible]	11	0	19	795	0
1947	3	57	7	1	28	[illegible]	0	[illegible]	0	0	0	0	0	0	0	16	162	0	2	6	0	0	0	0	22	253	7
1948	1	11	0	0	0	0	1	67	0	0	0	0	[illegible]	126	1	11	350	1	0	0	0	2	59	0	17	613	2
1949	1	7	0	0	0	0	0	0	0	[illegible]	0	0	[illegible]	0	0	10	218	0	2	4	0	2	17	0	15	246	[illegible]
1950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	54	[illegible]	[illegible]	8	[illegible]	0	0	0	10	62	[illegible]
Total 1923-1950	447	7,531	548	28	1,091	22	204	19,257	182	18	324	13	23	1,554	21	251	11,260	20	46	359	3	23	770	4	1,040	42,146	813
Total 1961-1966				9*	104*								2	242		5	107		?	113		[illegible]	57		19	623	

* Salmonellosis

Corynebacterium diphtheriae. This organism occasionally finds its way into the milk from the throat or nose of a human carrier or case of diphtheria. Sometimes it becomes implanted on ulcers of the cow's teats. Such an occurrence is peculiarly dangerous since the milk becomes in this way uniformly infected. Pasteurization destroys these organisms.

Escherichia-Aerobacter. This group is ordinarily not pathogenic for man, but in cows it has been found to be responsible for 5 - 10% of the cases of mastitis. Pasteurization destroys these organisms, except for a few heat tolerant types.

Typhoid, Paratyphoid, Food-poisoning, and Dysentery Bacilli. These important pathogenic organisms, which may occasionally contaminate the milk, are usually derived from human or other extraneous sources. Of all typhoid epidemics in U.S. since 1930 caused by milk, over 95% have been due to raw milk. Pasteurization destroys these pathogens.

Rickettsia burneti, the causative agent of "Q" fever, has been isolated from milk. Although cattle and sheep are common reservoirs of this microorganism and the tick is generally suspected as the important vector, milk is a potential means of spread. Pasteurization destroys this organism.

Streptobacillus moniliformis, the causative agent of Haverhill fever, has caused several epidemics by way of raw milk. The rat is considered the usual vector and the disease can be transmitted by the rat bite. Pasteurization destroys this organism.

Enzymes in Milk

Various enzymes are normally present in milk. The principal ones which are usually regarded as present are:

Galactase - This enzyme is a protease and curdles and peptonizes casein. It is inactivated by heat at 165°F. to 175°F.

Peroxidase - This enzyme facilitates the oxidation of readily oxidizable substances by transferring oxygen to them from some peroxide. It appears to have little influence in causing deterioration of dairy products. It is inactivated at a temperature of 158°F. Although this enzyme cannot be used to test whether milk has been adequately pasteurized at 143°, it may be used to detect whether milk or milk products have been heated to comparatively high temperatures.

Catalase - This enzyme splits hydrogen peroxide into water and molecular oxygen. It is apparently unimportant in milk. It is destroyed at 158°F. The catalase content of milk is increased by mastitis.

Amylase - This is a starch-splitting enzyme and the least variable found in milk. The amylse content of milk is increased when mastitis is present. It has been suggested that this emymes may be used as a test of mastitis.

Lipase - This is a fat-splitting enzyme that aids the hydrolysis of fat into fatty acids and glycerol with resulting rancidity when such fatty acids as butyric and caproic acids are produced. This enzyme is variable in milk. Some raw milk will become rancid quicker than others. It is destroyed at 140°F. for 10 minutes. Since homogenization of milk exposes more surface of fat to chemical action, homogenized raw milk will become rancid more quickly than when not homogenized. Lipase should be destroyed by pasteurization before homogenization if rancidity is to be delayed.

Phosphatase. This enzyme is always present in milk. In mixed milk, its concentration is fairly constant. It is destroyed by heat at 143°F. for 30 minutes, or 160°F. for 15 seconds, and therefore is a perfect indicator of adequacy of pasteurization. It is used for this purpose in the phospatase test.

Aldehydase (Shardinger's Enzyme). When milk contains a suitable oxidant, this enzyme aids the oxidation of aldehydes. It is capable of reducing methylene blue to methylene white in the presence of aldehyde.

Other Enzymes. Lactase and salolase are sometimes said to be present in normal milk. With the exception of lipase and phosphatase, the enzymes in milk are of little importance from a market-milk standpoint, although galactase is important in cheese production.

Bacterial Enzymes. Bacteria elaborate enzymes in order that they may utilize nutrients for growth and energy. The bacterial enzymes include various proteases which are utilized in the production of cheese, various amylases also utilized in fermenting and cheese processes, various lipases which are sometimes utilized in developing flavors in cheese and butter but which may cause rancidity, various oxidases and reductases. The bacterial reductase found in raw milk is utilized in testing for the relative quantity of bacteria in raw milk. The latter is called the methylene blue or reductase test.

Quality in Milk

Quality is a composite, not a single attribute of milk. There are, for example (1) The nutritive quality, (2) the cleanliness, (3) the keeping quality (4) the pasteurizability, and (5) the safety of milk, to mention only five of its most important attributes. Leaving aside the nutritive quality, which can be determined only by chemical analysis and animal feeding experiments, we may consider for the moment what we mean by the other four properties.

By cleanliness is generally understood the freedom of the milk from extraneous matter, from blood, and from an undue number of leucocytes (white blood cells) and bacteria. It is an unsatisfactory term, but by general usage it has come to bear this meaning.

By keeping quality of the milk is meant the length of time it will remain sweet and free from odors and tastes that render it unpalatable.

The pasteurizability of the milk is a term devised to indicate the suitability of the milk for heat treatment. It is a mistaken idea that any milk can be pasteurized. A milk that is too acid will clot when the temperature is raised, and the resultant product will have to be discarded. Again, some milks contain large numbers of heat-resistant bacteria which are not destroyed by pasteurization and which prevent the pasteurized product from conforming to the legal standards.

The safety of milk is a term denoting the freedom from bacteria and poisons capable of giving rise to disease in man. It is confused by some with the term cleanliness, but there is no constant relationship between these two properties. Dirty milk, if free from pathogenic bacteria, may be quite safe, while very clean milks are not infrequently dangerous.

For human consumption it is desirable that milk be both clean and safe. Clean milk is more aesthetically desirable, it has a better flavor, and it keeps longer. Moreover, it is not likely to contain any of those toxic substances resulting from undue bacterial growth which have an irritating effect on the gastro-intestinal tract —particularly of infants. The fewer organisms there are in milk and the more their growth and reporduction are checked, the less liable is the milk to give rise to digestive disturbance.

As regards safety, it will be clear that no raw milk can ever be regarded as completely safe for human consumption. The frequency of disease in cattle, the risk of contamination from human and other sources, and the suitability of the milk itself as a medium for bacterial multiplication combine to render the consumption of raw milk potentially dangerous. The only satisfactory way of eliminating this danger is by pasteurization or some form of adequate heat treatment.

Bacteriological Grading of Milk by Bacterial, Cellular, and Sediment Tests:

From a public health point of view, it is usual to grade milk by the bacterial count, by the cleanliness and by its safety. The various methods available for these purposes will be briefly considered.

Sampling. Since the answer given by any test is determined so largely (a) by multiple factors involved in the production and subsequent handling of the milk, (b) by the care with which the milk is sampled, and (c) by the time-temperature conditions under which the sample is taken and kept prior to analysis, it follows that it is unwise to pay too much attention to the results of any single examination. The most satisfactory procedure is to make frequent and regular examinations of

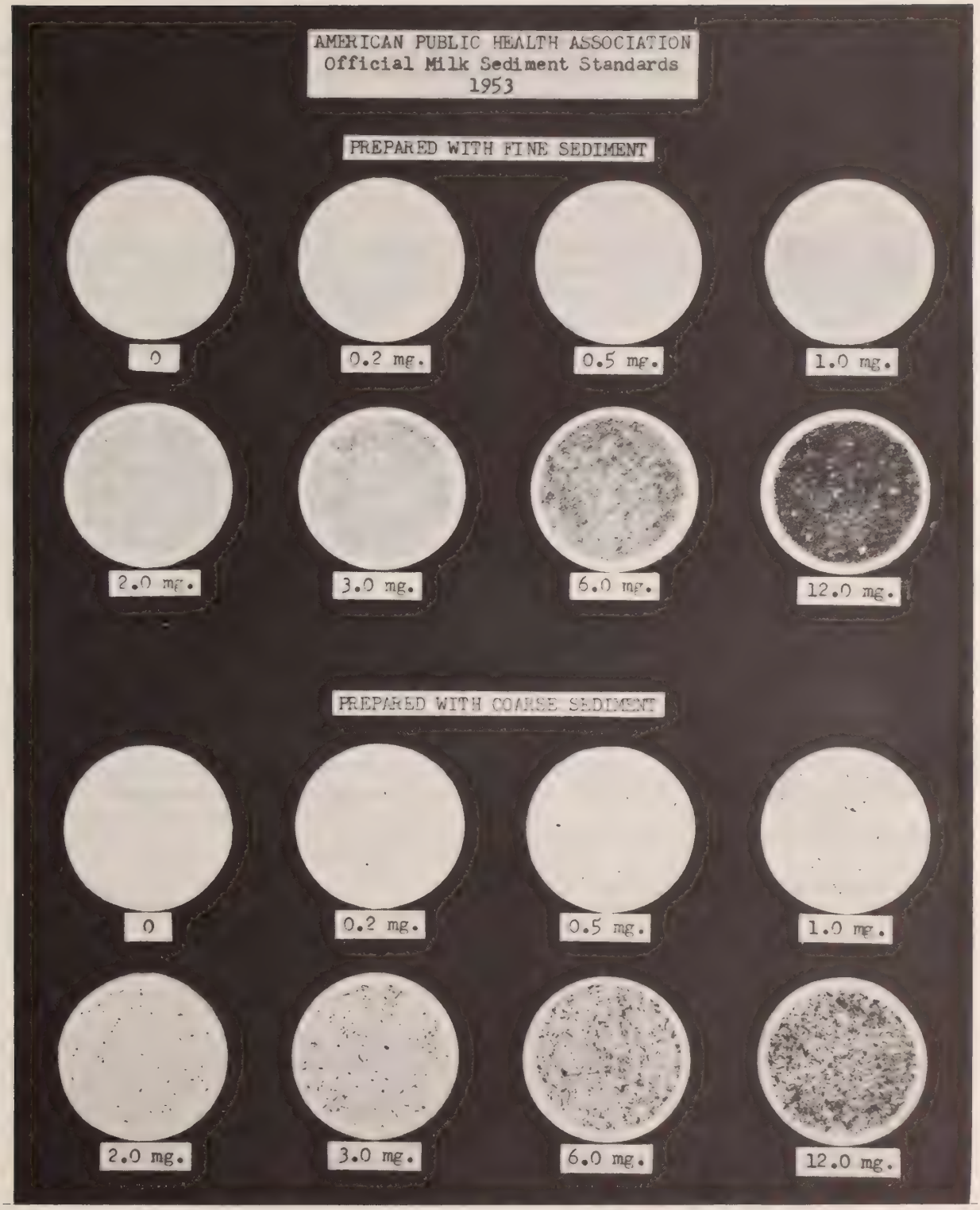

AMERICAN PUBLIC HEALTH ASSOCIATION
Official Milk Sediment Standards
1953
PREPARED WITH FINE SEDIMENT
0
0.2 mg.
0.5 mg.
1.0 mg.
2.0 mg.
3.0 mg.
6.0 mg.
12.0 mg.
PREPARED WITH COARSE SEDIMENT
0
0.2 mg.
0.5 mg.
1.0 mg.
2.0 mg.
3.0 mg.
6.0 mg.
12.0 mg.

Fig. 1

the milk of any given producer throughout the year and to insist that a given proportion of the samples should come up to a given standard. In this way, some allowance will be made for factors over which the producer is unable to exercise complete control, while at the same time insuring that the conditions of production as a wholeare kept at a reasonably high level.

Every endeavor should be made in the sampling of the milk to obtain a homogeneous distribution of organisms and fat. If the intention be to test the cleanliness of production, it is desirable to expose the sample, after collection, to an agreed temperature for a given length of time in order that the latent contamination in milk produced under bad conditions may have time to develop. When testing milk delivered to the consumer, on the other hand, it is desirable to ice the sample at once so as to obtain information on the degree of bacterial contamination at the time of delivery by the distributor.

The Sediment Test. The amount of extraneous matter in milk is determined usually by filtration through a cotton pad, but may be done by centrifugation. Dust or sediment indicates carelessness in cleaning the udders, dust from stable air or feed that settles in the milk, dirty milk pails or other dirty equipment, or inflamed udders which yield flaky material composed of leucocytes and epithelial cells matted together. The ordinary sediment tester is a hand operated apparatus resembling an automobile tire pump. It consists of a hollow tube and a plunger. The tube is fitted at the bottom with a valve that holds a filter pad in place. After the milk is well agitated, the tube is filled with milk as the plunger is withdrawn. Then the plunger is forced in again and the milk is forced out of the tube, passing through the filter pad in doing so. The pad is then taken out of the tester and graded in accordance to the amount of sediment collected (Figure 1). Recently, electrically operated sediment testers have been devised, allowing large scale operation quickly and easily. A simple sediment test of this sort is of value in controlling the gross dirt in milk and in educating the unhygienic farmer. Since, however, filtration through muslin gauze on the farm will remove dirt of this type, the absence of an obvious sediment must not be taken to mean that the conditions of production are satisfactory. Most of the bacteria in milk come not so much from gross dirt, but from uncleaned utensils.

The Cellular Content. Milk from normal udders contains, as a rule, less than 100, 000 cells per c. c. But the perfectly normal udder is almost a curiosity because it is so rare. Therefore, for practical purposes we must allow a considerable margin for this figure. Some workers claim that the range of the cell count for milk from the average apparently normal udder is from 200, 000 to 1, 000, 000 per c. c. An abnormally high cell count may be due to:

1) Retention of the milk in the udder, causing acute and chronic inflammation.

2) Various types of inflammatory diseases.

3) The period approaching the end of lactation.

4) The period approaching calving time.

5) The period of excitement.

Usually we consider that milk containing more than 500, 000 cells per c. c. has come from an abnormal udder. A mere count of the cells affords little information about the quality of the milk, and it would be unwise to condemn a milk solely on account of an increased cell content. If long-chain streptococci or red blood cells or both be found in addition, the probability is that the cow is suffering from mastitis. Mastitis can be caused by other bacteria than streptococci, but this genus is the causal agent in 65-70% of the cases. Much more information can be obtained by a differential count of the cells (estimating the percentage of various types of cells present), but the real value of this method lies in the help it gives to the veterinarian who is engaged in a study of the individual cow.

Direct Microscopic Method. The general technique of this method is to spread 0. 01 c. c. of milk over one square centimeter of surface on a specially inscribed area. After drying of milk on slide, the fat is removed with xylene and then stained with methylene blue stain. Under the microscope the number of individual bacteria (dead and alive) are counted and the number per c. c. is calculated. The cells may be counted by this method. Counts are usually

not made unless needed to establish the correct assignment of the grade of the milk. Normally it is possible to determine whether the milk be excellent, good, unsatisfactory, or very unsatisfactory by examining the character of the smear without counting the bacteria. Official counts and grades made by this method are to be considered on their own merits and not strictly interpreted in terms of standard plate counts. There is no constant relation between the total individual bacterial count by the microscope and standard agar plate count. The microscopic count ranges as high as ten times greater than the plate count, but the most frequent ratio between the counts of these two methods is 4:1.

The presence of specific bacterial types, whether in high or low counts, indicates with reasonable accuracy the conditions causing their presence; for example, the presence of long-chain streptococci indicates mastitis as the cause; the presence of spore-forming bacteria, micrococci, and various yeasts and molds may indicate air or dust as the cause; the presence of Escherichia-Aerobacter types indicates contamination by manure, soil, feeds and bedding; the presence of Streptococcus lactis and alcaligenes viscosus may indicate unclean utensils as the cause; the presence of Streptococcus lactis, rods and cocci, and Oospora lactis may indicate contamination from unclean machines. Such interpretations are quite valid if not more than ten gallons of milk be mixed as in an individual can, and the age and temperature of the milk be known. Larger amounts of milk will give less reliable results. In examining pasteurized milk or cream, it must be kept in mind that much of the "normal" flora is killed, that thermophilic or thermoduric bacteria may have increased to predominance, that contamination from equipment may add more bacteria, and that psychrophiles may have increased if stored at low temperatures.

The applications and advantages of the Direct Microscopic Method:

1) It allows a rapid examination for the purpose of assigning grades to samples.
2) It facilitates the detection of poor quality milk at the receiving station and leads to the direction of the most probable cause of high counts in raw milk.
3) It is a rapid method for making a numerical estimate of the bacteria.
4) Although Direct Microscopic and plate counts should not be interpreted in terms of each other, the former may be used as an empirical method for deriving an estimated plate count.
5) It allows the detection of those distinctive bacteria associated with poor hygienic conditions.
6) It requires less apparatus, is a simpler technique, is less expensive, yields information within 15 minutes, gives evidence of cellular as well as bacterial content at same time.
7) It gives a better index of the actual number of microorganisms present.
8) It gives a permanent record of the evidence.

Direct Microscopic Method.

Even when great care is taken, grading by the direct microscopic method may be much more lenient than by the Standard Plate Count. The accuracy of estimates by the miscrscopic method is highest with high-count milks, falling off progressively as the count level declines. Actually, the direct microscopic method should not be used on milks of very low count.

Applications to Raw Milk to be Pasteurized

The microscopic method offers a rapid technic for determining the extent of bacterial contamination in raw milk or cream samples taken directly from the producer or from pooled supplies in tankers or storage tanks. Individual samples may be examined in 10-15 min. The arrangement of bacterial cells in the stained film may suggest a possible cause of a high count, while excessive numbers of leucocytes point to abnormal udder conditions, especially mastitis. Such interpretations always should be made cautiously even by well-trained analysts. When actual counts are to be reported, when litigation may be involved, or when other exacting situations may exist, actual numerical estimates may be made.

Applications to Pasteurized Milk

The microscopic method may be used to determine the extent of bacterial contamination in pasteurized fluid milk and cream. Because dead cells lose their stainability to some degree and generally only very low numbers of viable bacteria occur in pasteurized products, this method should not be used to determine compliance with finished product standards but should

be used only as an aid in troubleshooting.

Applications to Powdered Milk

Most powdered milks contain only relatively small numbers of viable bacteria. Microscopic examination of films prepared from reconstituted samples can provide information on the previous history of the product and may be useful in quality control programs. Direct microscopic clump counts have been established as the basis for certain government standards and also have been incorporated into industry standards. Arguments have been presented against their use, and evidence has appeared indicating that wide variations on the same samples might be expected between laboratories. Also, the relationship between the direct microscopic counts of skim milks and the corresponding powders made from them was found to vary widely. The effects of heat on the stainability of bacteria in dry milk should be recognized.

Sources of Error in Method

As with other methods for assessing the bacterial content of milk, results by the direct microscopic method are estimates only. The training and experience of the analyst are prime factors in determining the accuracy, reproducibility, and significance of the results obtained. Even with the most exacting technic, replicate estimates may vary appreciably. Among factors responsible for variation are:

1. Inaccuracy in measuring 0.01 ml. quantities
2. Faulty preparation and staining of slides
3. Failure of bacteria to stain
4. The minute amount of milk actually examined in counting
5. Irregular distribution of bacteria in the films
6. Failure to count a sufficient number of fields
7. Mistakes in observation and calculation
8. Poor microscopy: inadequate or excessive illumination of the microscope, poor focusing, and improper use of colored filters
9. Fatigue

Bacterial Estimates

When large numbers of bacteria are present and are uniformly distributed, films from poor-quality milk will show numerous clumps per field examined, whereas films from high-quality milk contain few or no bacteria in many fields. Thus, the examination of only several fields often will indicate the general quality characteristics of the sample. Since either the presence or absence of bacteria may be determined readily, both high-quality and poor-quality samples may be recognized easily.

While there may have been, in the past, some justification for rapid examination to classify samples quickly into several quality categories, there is less tendency to do this at the present time, and each direct microscopic examination becomes basically an enumerative procedure. This is particularly true of the higher quality milk being produced today that is separated into an increasingly larger number of grades based on both regulatory and industry standards.

There is the need for examination of an appropriate number of fields to provide significant results, particularly with milk samples of good quality. The determination of numerical estimates of clumps requires careful and extensive efforts regarding inspection of individual fields and the number of fields to be examined. Because of uneven distribution of bacterial clumps, especially in low count samples, actual estimates should be reported only after careful examination of not less than the minimum number of fields specified. Unless otherwise specified, microscopic counts should refer only to clump counts (DMC/ml).

Where results are to be expressed as grades rather than as clump estimates, this may be done, but at no sacrifice to the number of fields to be counted. The enumerative aspects of the procedure must be stressed from the standpoint of developing confidence in and significance of results, because the results are being used generally as actual estimates rather than as mere indications of grade. It must be cautioned that unwarranted accuracy cannot be attached to these results, which are indeed only estimates subject to rather wide ranges in variability.

To avoid creating false impressions of accuracy when interpreting and reporting estimates of bacterial clumps, only the first two left-hand digits in estimates should be reported, followed by zeros as required in recording standard plate counts.

Standards

Raw milk intended for manufacturing purposes is generally subject to more liberal standards than that for fluid milk purposes. Proposed USDA standards include three classes of milk differentiated by limits of 500,000 and 3,000,000 per ml. direct microscopic clump count. Standards adopted by several product groups in the industry are even more liberal.

Standards based on determinations by the direct microscopic method generally have not been established for pasteurized milk products. However, USDA and industry standards are being applied currently to dry milk and include maximum limits of 75,000,000 and 200,000,000 per g. direct microscopic clump count for two classes of product.

Interpreting Causes of Poor Sanitary Quality in Raw and Pasteurized Samples

In the past, one advantage claimed for the direct microscopic method has been its usefulness in indicating possible causes of high bacterial numbers, i.e., udder infections, contamination from utensils, or bacterial growth. Because of improvements in milk production methods and consequently milk quality, such interpretations in the case of dirty equipment and poor cooling cannot be made consistently with any degree of reliability.

Abnormal milk - Microscopic examination is very useful in detection of abnormal milk. Although udder infections are often blamed for high counts, they are rarely the cause. However, leucocytes are readily and commonly observed. Their presence in large numbers (over 500,000 per ml.) in herd milk strongly suggests a significant incidence of mastitis. Leucocyte estimates are made differently from bacterial estimates in that individual leucocytes are counted rather than clumps. Care must be taken to count nuclear lobes of the same leucocyte (neutrophil) as one cell.

A variety of organisms may be involved in udder infections. More than 95% of all cases of mastitis are caused by a few species of streptococci and staphylococci. Another one or two percent may be caused by a few species of rod-shaped bacteria. Most of these organisms cannot be identified by microscopic examination. However, films made from milks of individual cows or more rarely from milk of a given herd may show longchain streptococci and leucocytes. Such organisms will be observed less abundantly as milk is diluted by pooling milk from other cows and herds.

Utensil contamination - Where utensil contamination has occurred, bacterial clumps, often arranged as mixtures of either or both micrococci and rods, appear in films as large irregular sheets or masses of cells.

Poor cooling - Where poor cooling has occurred, bacteria frequently appear in films as pairs of spherical cells slightly elongated. However, with most market milk supplies, this picture is not so typical at the present time.

In milk products which have been subjected to conventional pasteurization or greater heat treatments, bacteria killed by heat generally lose the ability to take up stain to a greater or lesser degree. Considering present-day raw milk quality and processing efficiency, direct microscopic examination cannot be considered reliable for detecting unsatisfactory finished fluid milk products.

However, bacteria in large numbers in stained films prepared from pasteurized products, regardless of type or viability, indicate undesirable conditions. Such observations may be used to supplement agar plate methods to reveal sources of contamination in solving quality control problems related either to raw milk quality or to processing. Thermophilic, thermoduric, and psychrophilic bacteria may, on occasion, be detected by microscopic examination, but cultural methods are more meaningful, although more time-consuming.

Agar Plate Method

For many years, the chief cultural procedure for determining viable bacterial populations has been the agar plate method. This is a highly empirical technic because bacteria occur singly, in pairs, chains, clusters, or packets. Consequently, the number of colonies which develop per milliliter or per gram of sample may frequently be lower than the actual number of individual cells present. In addition, some bacteria, because of injury, requirements for special nutrients, reaction to oxygen, unfavorable incubation temperatures, or other factors, are unable to form visible colonies under the conditions employed in the standard procedure. Because the method is an empirical one, the competence and accuracy of the analyst are extremely significant. Despite these factors, the agar plate method is of considerable value. It is suitable for estimating bacterial populations on most types of dairy products, especially where microbial densities are low, as in pasteurized products. It is also the basic procedure approved by the American Association of Medical Milk Commissions for analyzing certified milk. The U.S. Public Health Service stipulates this method for the examination of pasteurized milk and milk products in the Grade A Pasteurized Milk Ordinance, 1965. It is also recommended for detecting sources of contamination by testing "line samples" taken at successive stages of processing.

A more complete picture of the bacterial condition of milk may be obtained by incubation of additional plates at various temperatures for varying times.

Selecting Dilutions: For normal routine control, not less than two plates should be prepared per sample, selecting dilutions so that the total number of colonies on at least one plate will be between 30 and 300. For example, where Standard Plate Counts per ml. are expected between 10,000 and 300,000, prepare plates containing 1:100 and 1:1000 dilutions. In many industrial laboratories, it is common practice to employ single plates of a single dilution for routine control of supplies and plant operating samples when repeated experience has established the dilution of choice that would most likely give a plate with 30 to 300 colonies. If this practice be followed, it is recommended (1) that the record of results show when an analysis is based upon a plate having a number of colonies outside the limits of 30-300; and (2) that such supplies be rechecked promptly, using two or more dilutions with two or more plates.

Preparing samples: Thoroughly and vigorously mix contents of each container immediately before removal of any sample, to ensure representative portions. Full retail containers should be inverted repeatedly until contents are homogeneous before removal of test portions. If necessary to ensure a homogeneous sample, the products from the filled cartons should be poured back and forth into a sterile container. Before opening a sample container, remove from closure all material which may contaminate the sample. When deemed advisable, wipe the top of unopened containers with sterile cloth saturated with 70% alcohol.

Each container should be shaked by 25 complete up and down movements of about 1 ft. in 7 sec. before transferring test portion of milk or cream (except from filled containers, as noted above) and of dilutions thereof. Identify each plate before making dilutions. The date, plating time, and dilution for each set of samples should be recorded, and plates identified accordingly.

Plating: The required amount of medium is quickly melted in boiling water or by exposure to flowing steam in a partially closed container, but prolonged exposure to unnessarily high temperatures should be avoided during and after melting. If the medium be melted in two or more batches, all of each batch should be used in the order of being melted, provided that the contents in separate containers remain fully melted. Media that have been held in the melted state for more than 3 hr. should be discarded. Resterilization of media may cause partial precipitation of ingredients and should be avoided.

The melted medium should be cooled promptly to about 45° C. (113° F.) and held at 44-46° C. (111° - 115° F.) in water bath or incubator until used. A thermometer should be placed into the water in a separate container at a similar depth as that used for medium also exposed to the same conditions as the medium to serve as a temperature control.

The sense of touch should not be depended upon to indicate the proper temperature of medium when pouring agar.

The number of samples to be plated in any one series should be selected so that not more than 20 minutes would elapse between diluting the first sample and pouring the last plate in the series. (Should a continuous plating operation be conducted by a team, the work should be planned so that the time between the initial pouring of a test portion into diluent or directly into a dish and the pouring of the last plate for that sample is not more than 20 min.). 10 to 12 ml. of liquefied medium at 44° -46° C. should be placed in each plate by gently lifting the cover to the petri dish just high enough to insert the pipette or to pour the medium. Spilling of the medium on outside of the container or on the inside of the plate lid when pouring should be avoided. As each plate is poured, thoroughly mix the medium with the test portions in the petri dish (taking care not to splash the mixture over the edge) by rotating the dish first in one direction and then in the opposite direction, or by rotating and tilting the dish, or by using mechanical rotators. Having spread the mixture evenly over the bottom of the plate, allow it to solidify (within 5 to 10 min.) on a level surface. After solidification, the plates should be inverted (if clay tops or other absorbent tops be used, the inversion is optionally omitted) and promptly placed in the incubator.

Incubation, Standard Plate Count: Unless containers used for convenient handling of plates permit plates to reach the temperature of incubation promptly (2 hr. interval), the plates should be removed from such containers during incubation. Plates are incubated at 32° C. ± 1° C. for 48 hr. ± 3 hr. for the Standard Plate Count.

Air temperatures are unreliable indexes of actual agar temperatures. Therefore, the entire thermometer bulb should be inserted in a small, tightly closed bottle or flask and be completely surrounded by water or other liquid. Since temperatures near the top of incubators usually are incorrect indexes of temperatures throughout the chamber, temperatures are determined by using not fewer than two thermometers, one placed on the top shelf and one on the bottom, and additional thermometers as needed at intermediate points where plates are incubated.

Daily records are kept of temperatures (early AM and late PM readings suggested) in areas used for incubating milk plates, especially where such temperatures may vary or where records may be required for legal testimony.

Use of automatic devices of predetermined accuracy for controlling and recording temperatures is optional. To determine continued conformance, automatic controls are periodically supplemented with readings from standard thermometers. To indicate whether undetected gross temperature deviations occur and the degree of such deviations, it is best to install maximum- and minimum-registering thermometers in each incubator. Do not depend upon readings from these thermometers for daily records of temperatures. If recording thermometers be in continuous operation, maximum- and minimum-registering thermometers are necessary.

Excessive humidity in the incubator should be avoided to reduce the tendency for spreader formation, but excessive drying of the medium should be prevented by controlling ventilation and air circulation. Agar in plates should not lose weight by more than 15% during 48 hr. incubation.

Control plates should be made for each series of samples (if appreciable time elapses between series) and of dilution waters and media to check for sterility. Since the number of samples in a series may vary considerably, the intent of this recommendation can be met by a minimum of one control plate for samples plated in the morning and another control for samples prepared in the afternoon. If colonies still appear on control plates, testing for contamination of media, water blanks, plates, and pipettes as well as air contamination should be done.

If groups of successively poured plates or groups of samples show peculiar trends for higher or lower counts than expected, this observation should be noted when making counts, then an investigation should be made to determine the cause.

Colony Counting Aids. Colonies are counted with the aid of magnification under uniform and properly controlled artificial illumination. The Quebec colony counter or its equivalent, dark-field model preferred, equipped with a guide plate ruled in square centimeters is used. The total colonies are recorded mechanically, using a hand tally. Mistaking particles of undissolved medium, precipitated matter, or dirt specks for pinpoint colonies should be avoided.

All colonies should be counted promptly on selected plates after the incubation period. If it be not possible to make the counts at once, the plates should be stored after the required incubation period at approximately 5° C. (41° F.) for not more than 24 hr. This should be avoided as a routine practice. When counting colonies on plates from individual samples, the following rules should be observed:

Rule 1. One plate with 30 to 300 colonies. Spreader-free plate with 30-300 colonies is selected. All colonies are counted, including those of pinpoint size on selected plate, dilution used is recorded and total colonies are reported as basis for official Standard Plate Count. See Table 2, Sample No. 1.

Rule 2. Duplicate plates. (1) If more than one plate of a certain dilution be prepared but only one plate yields 30-300 colonies, the other duplicate plate or plates are counted unless excluded by Rule 4 or 7, and the arithmetic average is included. See Table 2, Sample Nos. 11 and 12. (2) When one or more duplicate plates from consecutive decimal dilutions are to be counted, the average count per dilution is determined before proceeding with Rule 3. See Table 2, Sample Nos. 13, 14, and 15.

Rule 3. Consecutive dilutions (30 to 300 colonies). If plates from two consecutive decimal dilutions yield 30-300 colonies each, the estimated count per ml. is estimated for each dilution by multiplying the colonies per plate by the dilution used, and the arithmetic average is reported as Standard Plate Count per ml. unless the higher computed count be more than twice the lower one, in which case the lower computed count is reported as Standard Plate Count per ml. See Table 2, Samples Nos. 2 and 3.

Rule 4. Spreaders. If spreaders occur on the plate selected, count the colonies on representative portions thereof only when (1) the colonies are well distributed in the spreader-free areas and (2) the area covered by the spreader, including the total repressed-growth area, if any, does not exceed one-half of plate. Where the repressed-growth area alone exceeds one-quarter of the total area, the test is reported as directed in Rule 7.

Rule 5. No plate with 30 to 300 colonies. If there be no plate with 30-300 colonies and one or more plates have more than 300 colonies, the plate having a count nearest 300 colonies is used, counting and estimating numbers per plate as in Rule 1. See Table 2, Sample Nos. 4 and 10.

Rule 6. All plates with fewer than 30 colonies. If plates from all dilutions yield fewer than 30 colonies each, the actual number of colonies on the lowest dilution (unless excluded by Rule 4 and Rule 7) is recorded, but the computed count is reported as "less than" 30 times the corresponding dilution. For example, if the 1:100 dilution has been used, the Standard Plate Count per ml. is reported as "less than 3,000" ($< 3,000$). See Table 2, Sample No. 7.

Rule 7. Laboratory accidents, bacterial growth inhibitors, etc. If all plates from any sample (1) show no colonies, (2) have excessive spreader growth, (3) are known to be contaminated, or (4) are otherwise unsatisfactory, the report is made as one of the following: "no colonies" (NC), "Spreaders" (Spr.), "Laboratory accident" (LA), or "Growth inhibitors" (GI). See Table 2, Sample Nos. 8 and 9. In plates which show no growth or which show proportionately less growth in lower dilutions, the analyst may be inclined to suspect the presence of inhibitors. The presence of inhibitors must be determined by an appropriate test designed specifically to detect such materials.

Rule 8. Computing and recording counts. To compute the Standard Plate Count per ml., multiply total colonies, or average, or estimate number per plate by the reciprocal of the dilution used.

When recording counts, use not more than the first two left-hand digits. See examples in

Table 2. Report as Standard Plate Count per ml.

If the colonies per plate appreciably exceed 300, the colonies in the portions of the plate that is representative of the colony distribution is counted and from this is estimated the total number per plate. If there be fewer than 10 colonies per cm^2, the colonies in 13 squares are counted, selecting 7 consecutive squares horizontally across the plate and 6 consecutive squares at right angles if they be representative, being careful not to count a square more than once. (Sum of colonies in 13 representative square centimeters multiplied by 5 yields estimated colonies per plate when area of plate is 65 cm^2).

When there are more than 10 colonies per cm^2, the colonies in 4 such representative squares are counted. The average number found per cm^2 is multiplied by appropriate factor to determine the estimated colonies per plate. Because the average inside diameter of the bottom of the recommended type of petri dish is 91 mm., the average number of colonies per cm^2 is multiplied by 65. Dishes with flat bottoms are used to avoid errors among the estimates caused by the unequal distribution of colonies depending upon varying depths of the media in the plates. Caution: If pressed-glass dishes or single-use plastic dishes with a smaller diameter be used, the laboratories should determine the actual diameters and use the correction factor for multiplication.

Table 2. Examples for Computing Standard Plate Counts Per Milliliter

Sample No.	Colonies/dilution 1:100	Colonies/dilution 1:1000	Count ratio[1]	Standard Plate Count at 32° C.	Rule (s) applicable under
	Common application where two plates, and from each of two decimal dilutions, are poured				
1	234	38	-	23,000	1
2	293	41	1.4	35,000	3
3	140	32	2.3	14,000	
4	Spreader[2]	31	-	31,000	
5	1365	Spreader[2]	-	LA	
6	*	355	-	360,000	5
7	18	*	-	3,000	6
8	0	0	-	NC	7
9	Spreader[2]	5	-	LA	7
10	325	25	-	33,000	5
	Procedure where two or more plates per dilution are poured				
11	175	16	-	19,000	2
	208	17	-		
12	322	23	-	30,000	2
	278	29	-		
13	296	40	-	33,000	2
	378	24	-		
14	138	42	2.4	15,000	2
	162	30	-		
15	274	35	1.4	30,000	2
	230	Spreader[2]			

1. Count ratio is the ratio of the greater to the lesser plate count, as applied to plates from consecutive dilutions having between 30 and 300 colonies.
2. Spreader and adjoining area of repressed growth covering more than one-half of plate.
* Not counted because colony count of other dilution is above (or below) desired range.

Counts on crowded plates from highest dilution are not reported as too numerous to count (TNTC). Where bacterial counts on crowded plates (greater than 30 colonies per cm^2) are obtained using the estimation procedures not in accordance with standard procedures, appropriate terminology is used in lieu of "Standard".

When the counting of spreading colonies cannot be avoided, each of the three distinct types are counted as one source. The first type is a chain of colonies, not too distinctly separated, that appears to be caused by disintegration of a bacterial clump when the petri dish is rotated to mix agar with the dilution water. If only one such chain exists, it is counted as a single colony. If one or more chains appear to originate from separate sources, each source is counted as one colony. Each individual growth in such chain is not counted as separate colonies.

The second type is the spreader that develops in a film of water between the agar and the bottom of the dish. The third type is that which forms in a film of water at edge or over the surface of the agar.

The two latter types develop largely because of accumulation of moisture at a point from which the spreader originates. When dilution water is uniformly distributed throughout the medium, bacteria rarely develop into spreading colonies. Any laboratory which finds that 5% of the plates are more than one-fourth covered by spreaders should take immediate steps to eliminate this trouble. Conditions should be noted for reporting the results as laboratory accidents when spreaders cover more than one-half of plate.

Inaccurate counting resulting from carelessness, impaired vision, or failure to recognize colonies should be avoided. Laboratory workers who cannot duplicate their own counts on the same plate within 5%, and the counts of other analysts within 10%, should discover the causes and correct such disagreements.

When it is further pointed out that these clumps of bacteria may disintegrate to a variable and quite uncontrollable extent during the process of dilution, leading in extreme instances to errors of 1,000 percent, and that many of the individual steps in the technique of the count are very difficult to standardize, and even when standardized as nearly as possible are attended by a large experimental error, it will be realized that the figures yielded by the plate count are not merely arbitrary, but are also only approximate.

Even if it were possible to standardize the technique of the plate count, it would still be necessary to allow a margin of 50 to 90% on the result of any one milk, depending on the number of plates used for each dilution. Even this estimate would often fall short of the real variation met with in practice. However accurate the plate count may be for the enumeration of bacteria in pure broth cultures, it is plainly unsuitable for this purpose when applied to milk. Because the results are expressed quantitatively in figures extending over a wide range, they afford a fictitious appearance of accuracy which leads not only the laymen but even the public health officials to wholly unjustifiable feelings of confidence in their value. It is not denied that the plate count can be used as a rough yard-stick for the grading of milk, but it is denied that it can be used as a millimeter rule. It has been shown that a variation of 1° C. in the incubating temperature at 37° C. may cause samples of milk to vary from 10 to 90% of the maximum two day count, while a variation of 1° C. in incubating temperature at 32° C. causes only a 4% average variation in count. The use of a lower incubation temperature and better nutrient agar media has tended to give greater bacterial counts than by the older methods.

Variables Affecting Plate Count:

1) Stage at which the culture is obtained — from cow, from bottle, from pasteurization, etc.
2) Temperature at which milk is kept till count is made.
3) Sampling technique.
4) Temperature of incubation of plates.
5) Errors due to clumping of bacteria.
6) Variability of count due to other reasons known or unknown.

The plate count method allows the following which the microscopic method does not:

1) It shows the character of the growing bacterial colonies.
2) It shows only the living organisms.
3) It makes possible the isolation of pure cultures.
4) It shows (on gelatin) the "liquifier" bacteria, and, if litmus be used, the acid producer bacteria are indicated.
5) On low count milk it gives a better approximation of quantity.

The Keeping Quality Test. The milk is kept in special bottle at a given temperature such as 15° C. to 21° C., and examined every 8 to 12 hours until it becomes sour or putrid. As a general method for controlling the hygienic quality of the milk, this test performs a useful function, but the fact that the end-point is entirely subjective necessarily exposes the result to a very large experimental error.

The Coliform Test. Like the plate count, this method has been extensively used in the past for grading of milk without any real appreciation of the fundamental assumptions on which it rests. The determination of coliform bacteria depends upon:

1) The ability of the media used to differentiate this group from other types of bacteria.
2) The variation in the types of coliform bacteria from one area to another.
3) The variation of the sources of contamination (soil, feces, etc.) from one area to another.
4) The ability of the coliform group to grow in the material to be examined. (In water it does not seem to grow, and in milk it grows rapidly).

The coliform test does not indicate from what source milk has been contaminated, it merely indicates that contamination has taken place from human, soil or vegetation sources. If true Escherichia coli be found in milk, the source may be directly from cow-dung, manure, or human feces, or indirectly from unsterilized milk utensils in which bacterial multiplication has occurred. Unlike water, milk affords an admirable medium for the growth of coliform bacilli. If it be kept at a temperature of 10° C. or over, a great increase in their numbers may take place, a rise of several thousand-fold often occurring at 15° C. within 24 hours. Unless the milk has been kept at 4.5° C. or less, an estimation of the coliform bacilli affords only a very imperfect, and often entirely misleading index of the extent of the original contamination. With a milk produced and kept under ordinary conditions, it is impossible to tell how many of the coliform bacilli gained access at the time of production, and how many are due to the multiplication of those present at the beginning.

The presence of coliform bacilli in small number in water and milk, has, in the past, not been considered in itself as objectionable. But in recent years, the occurrence of coliforms in pasteurized milk or dairy products has come to be considered a matter of some sanitary significance. It is the consensus of most qualified opinion that few coliforms are sufficiently heat-tolerant to survive customary pre-heating and effective pasteurization of milk.

Control efforts should be directed toward reduction of the densities of coliform contamination of the raw milk supplies, the rejection of chronically contaminated supplies or their use in products and processing which assures their destruction. There is grounds for question of the widely held view that the coliform survivors of legally pasteurized milk are necessarily thermophiles or thermodurics, since it is possible that individual bacteria in the interiors of clumps may survive pasteurization and that the heat-tolerance of specific strains of bacteria may not be constant. Experience has indicated that the fewer the sources of a volume of milk, the more likely is the milk to have a larger population of coliforms. The sanitarian seeking the cause of high coliform counts in a raw milk supply should adopt a routine method of investigation such as:

1) Note whether the prevailing wind might carry dust from a pasture, grain-field, or straw-stack to the milking barn or milk house, and whether the dust can gain entrance thereto.
2) Note the state of repair and cleanliness of the equipment and utensils.
3) Note whether there may be a hay-loft over the milking space, and if so, how the hay is handled.
4) Note the degree of fly prevalence in the milking barn and milk house, and whether manure is available to them.

5) Ascertain whether the cows have access to a "tank" or pool of water or marshy area.
6) At milking time, note the condition of the cows' flanks and dustiness of the barn.
7) Note the nature of the sediment caught in the milk strainer discs, and the care of the unused strainer discs.
8) Note whether adequate facilities for cooling milk promptly are routinely used.
9) Note the conditions to which the milk is subjected during transit, and how long it is normally in transit.
10) Note whether any cows have coliform mastitis infection.
11) Note whether the water supply is satisfactory.
12) Note whether any hygienic malpractice exists on part of the milk handling personnel.
13) Note whether the milk is reconstituted, the source of the materials, and methods of reconstituting the milk.

In case of recontamination of effectively pasteurized milk, investigate as follows:
1) Equipment: Design, construction, and repair.
2) Physical conditions in the plant: Exposure of equipment and processing operations to contamination by dust from the exterior, or drip of condensate.
3) Exposure to insect contamination.
4) Operating practices which may favor recontamination.
5) Unhygienic practices of personnel.
6) Incomplete bactericidal treatment of equipment.

Coliform bacilli in milk are an index of the possible accompanying presence of pathogenic organisms but is not an index of direct excretal pollution. The coliform test on milk fails to provide us with that specific qualitative information which we hope for. Besides indicating needless contamination, the coliform test may serve a useful purpose in the examination of the highest quality of raw milk, since such milk often fails to show the presence of coliform bacilli in 1 c.c. quantities even several hours after production.

Coliform Bacteria*

The coliform group of bacteria includes all aerobic and facultatively anaerobic, gram-negative, non-sporeforming rods capable of fermenting lactose with the production of acid and gas at 32° C. within 48 hr. Bacteria of both fecal and nonfecal origin are members of this group and are classified into the genera Escherichia and Aerobacter. In addition, a few lactose-fermenting species of other genera are included. In proportion to the numbers present, any of these types is suggestive of unsanitary conditions or practices during production, processing, or storage.

The application of the test for coliform organisms is intended neither to detect fecal pollution specifically nor to identify Escherichia coli in dairy products, but rather to measure the quality of the practices used to minimize bacterial contamination of dairy products.

Such tests are used following pasteurization primarily to detect significant bacterial recontamination of milk and cream from:
1. Improper processing, which may be confirmed by positive phosphatase tests
2. Damaged or poorly sanitized equipment
3. Condensate dripping into pasteurized milk during or after pasteurization
4. Direct or indirect contamination of equipment by flies or other insects, or by the hands or garments of operators

Results of test on raw samples require different interpretations from those on pasteurized milk. Furthermore, without storage interval and temperature records for milk or cream before (and occasionally after) sampling, it is impossible to conclude from positive tests alone to what degree bacterial growth following initial contamination may have contributed to test results.

* Standard Methods for Examination of Dairy Products, APHA, 12th edition, 1967.

Coliform organisms in small numbers may enter raw milk and cream under normal conditions of production and handling. More commonly, coliform bacteria in raw milk are contaminants from:

1. Poorly cleaned and sanitized utensils.
2. Flecks of dirt, traces of manure, or hair dropped from the cow's body into milk during milking operation.
3. Udders washed and not dried.

With the increased use of farm bulk tanks and pipeline milkers, some laboratories are now using the coliform count on raw milk to determine the degree of contamination in milk production.

A positive test for members of the coliform group in milk and cream is indicated (1) when typical dark red colonies (normally at least 0.5 mm. in diameter) appear within 24 hr. ± 2 hr. after incubation at 32° C. on solid plating media such as violet red bile agar or desoxycholate lactose agar; or (2) when fermentation tubes containing brilliant green lactose bile broth (2%) show gas formation within 48 hr. ± 3 hr. after incubation at 32° C.

Verify doubtful colonies by transferring to 2% brilliant green lactose bile broth.

A positive "completed test" demonstrates that transfers from typical colonies on solid media or brilliant green lactose bile broth showing gas production will produce typical or atypical colonies on appropriate indicator media and that the pure cultures so isolated will produce gas in lactose broth fermentation tubes at 32° C. within 48 hr. and will consist only of gram-negative, nonsporeforming bacteria.

General Interpretations

Results of coliform tests have often been interpreted qualitatively, with too little emphasis on their quantitative significance. Results, even by the tube method, are sometimes reported without quantitative expression. Inadequate directions for interpretations may be partially responsible for the complacent tolerance in some quarters of relatively high coliform densities, for the unsatisfactory terms in which results of tests are sometimes expressed, and for the failure to specify limiting coliform densities in some sanitary codes. Because insufficiently sensitive tests will frequently fail to detect significant coliform densities, negative results should always be interpreted by plant operators and by control officials with due consideration of sample volumes tested.

Since determinations of total bacterial density in dairy products by agar plate and direct microscopic methods are reported per ml. or per g., the generally accepted practice when solid media are used is to report coliform determinations as "Coliform colonies per ml." (or per g.). Control administrators, dairy plant operators, and laboratory personnel are generally familiar with reports based on such quantities. Workers in some areas prefer to use the fermentation tube technic, which is the standard procedure in water and wastewater control laboratories, and to report results similarly: for example, as "Coliforms, Most Probable Number/100 ml." (or /100 g.), or "Coliforms MPN/100 ml." (or /100 g.). However, recent reports show a substantial mathematical bias in MPN values as compared with plate counts and, in the range of coliform densities investigated, the precision of plate counts was at least three times as great as that of replicate 5-5-5 tube MPN values.

With either method, however, other base reference units may be used, provided that coliform densities be expressed in truly quantitative and readily comparable terms.

Because of differences in the customary volume bases used for reporting determinations by each method, a positive result by the tube method reported per 100 ml. emphasizes recontamination at all levels more than the plate method. Such emphasis means that, in addition to focusing attention on samples containing appreciable recontamination, attention is also directed toward eliminating recontamination when coliform densities are not so high. Increased emphasis consequently should be attached to positive tests by the plate method when larger volumes are plated.

Potential health hazards occur roughly in proportion to coliform densities in commercial dairy products and related foods, especially if these products have been pasteurized. The coliform standards listed herein below are merely working limits to be used in routine control. Any positive result suggests recontamination, and indicates the need for improved plant sanitation. Regardless of the volume basis for reporting results, proper emphasis should be placed on all positive findings observed and the cause eliminated.

Reporting Results

Coliform densities are reported as "tests with solid media" and "tests with liquid media".

Tests with solid media. Results should be recorded by using only those plates with fewer than 150 colonies per plate. If plates from two consecutive decimal dilutions yield colony counts of 15 to 150, compute counts for each dilution by multiplying the number of colonies per plate by dilution used and report arithmetical average as coliform colonies per ml. or per g., unless the higher computed count be more than twice the lower one, in which case report the lower computed count. When less than 15 coliform colonies develop on plate(s) from diluted and/or undiluted samples, record results as observed. Indicate the number of plates and volumes used, and after necessary computations, report determinations as "Coliform colonies per ml. or per g.," using not more than two significant figures and substituting decimals for whole numbers when necessary. If no coliforms appear on plate(s), report "less than n/ml. (or /g.)," substituting for "n" the number that would be reported if only one coliform colony had been secured from the total volume plated. For example, if 2 ml. of undiluted milk had been plated, report results as "Coliform colonies less than 0.5/ml.".

Tests with liquid media. Results should be recorded by the number of tubes used, volumes introduced into each, and number of positive tubes; for example, if three of five tubes with 10 ml. portions in each show gas and none of five tubes with 1 ml. portions in each shows gas, record coliforms as:

(10 ml.)	(1 ml.)
3/5	0/5

The numerator indicates number of positive tubes and denominator, number of tubes planted. Interpret the laboratory report from tables, showing most probable number, and report "Coliforms MPN/ml." (or /g.), or where local regulations require, "100 ml." (or /100 g.).

Calculations of Most Probable Number of Coliforms

Where multiple-tube method is used, results may be reported as most probable number of coliform organisms per ml. (or /100 ml.) of sample. Table 3 shows the most probable numbers of coliforms, corresponding to the frequency of positive fermentation tests secured from a variety of multiple-portion planting systems, beginning with 10 ml. test portions. Since more than one organism may be responsible for each positive test, the probable number of organisms is a logarithmic function of results when test portions are decimally related as illustrated.

If the greatest volume planted be 1 ml., rather than 10 ml., multiply the most probable number listed in table by 10. Thus, the results, 1 ml. 3+ 0.1 ml. 1+ (meaning that 3 of 5 tubes with 1 ml. dilutions gave positives and 1 of 5 tubes with 0.1 ml. dilutions gave 1 positive) may be represented in the Table as 10 ml. 3+ 1 ml. 1+ and the corresponding most probable number, 11 per 100 ml., is multiplied by 10 to give 110 per 100 ml. as final most probable number of coliforms in sample. Similarly, if the greatest dilution planted be 0.01 ml., the most probable number listed in table is multiplied by 1,000. When more than three different volumes are employed, use results from three only, selecting the highest 5/5 below which no smaller result occurs and the two following. Significant results in the following examples are the ones that are not asterisked, therefore the asterisked figures are not to be utilized in computations.

	1 ml.	0.1 ml.	0.01 ml.	0.001 ml.
a)	* 5/5	5/5	2/5	0/5
b)	5/5	4/5	2/5	* 0/5
c)	0/5	1/5	0/5	* 0/5

In example (c), the first three volumes should be taken so as to throw the positive results in the middle volume.

If a positive test occurs in a volume smaller than the three chosen according to rule, example (d), then add the value appearing above the line for the smaller volume to value above line for the smallest chosen volume ($\frac{1}{5}$ and $\frac{1}{5}$ becomes $\frac{2}{5}$ and $\frac{0}{5}$), making result read as in example (e).

	1 ml.	0.1 ml.	0.01 ml.	0.001 ml.
d)	5/5	3/5	1/5	1/5
e)	5/5	3/5	2/5	* 0/5

When all tubes are positive, a "greater than" sign (>) is usually used, indicating that the most probable number is at least the one given or greater.

Table 3 Most Probable Number (MPN) per 100 ml of Sample and 95% Confidence Limits

Using 5 Tubes with 10, 1, and 0.1 ml Volumes

Five 10 ml Tube	Five 1 ml Tube	Five 0.1 ml Tube	MPN /100 ml	Limit MPN Lower	Limit MPN Upper	Five 10 ml Tube	Five 1 ml Tube	Five 0.1 ml Tube	MPN /100 ml	Limit MPN Lower	Limit MPN Upper	Five 10 ml Tube	Five 1 ml Tube	Five 0.1 ml Tube	MPN /100 ml	Limit MPN Lower	Limit MPN Upper
0*	0*	0*	<2	<0.5	—	3	0	0	8	1	19	5	0	0	23	7	70
0	0	1	2	<0.5	7	3	0	1	11	2	25	5	0	1	31	11	89
0	0	2	4	<0.5	11	3	0	2	13	3	31	5	0	2	43	15	114
0	1	0	2	<0.5	7	3	1	0	11	2	25	5	0	3	58	19	144
0	1	1	4	<0.5	11	3	1	1	14	4	34	5	0	4	76	24	180
0	1	2	6	<0.5	15	3	1	2	17	5	46	5	1	0	33	11	93
0	2	0	4	<0.5	11	3	1	3	20	6	60	5	1	1	46	16	120
0	2	1	6	<0.5	15	3	2	0	14	4	34	5	1	2	63	21	154
0	3	0	6	<0.5	15	3	2	1	17	5	46	5	1	3	84	26	197
1	0	0	2	<0.5	7	3	2	2	20	6	60	5	2	0	49	17	126
1	0	1	4	<0.5	11	3	3	0	17	5	46	5	2	1	70	23	168
1	0	2	6	<0.5	15	3	3	1	21	7	63	5	2	2	94	28	219
1	0	3	8	1	19	3	4	0	21	7	63	5	2	3	120	33	281
1	1	0	4	<0.5	11	3	4	1	24	8	72	5	2	4	148	38	366
1	1	1	6	<0.5	15	3	5	0	25	8	75	5	2	5	177	44	515
1	1	2	8	1	19	4	0	0	13	3	31	5	3	0	79	25	187
1	2	0	6	<0.5	15	4	0	1	17	5	46	5	3	1	109	31	253
1	2	1	8	1	19	4	0	2	21	7	63	5	3	2	141	37	343
1	2	2	10	2	23	4	0	3	25	8	75	5	3	3	175	44	503
1	3	0	8	1	19	4	1	0	17	5	46	5	3	4	212	53	669
1	3	1	10	2	23	4	1	1	21	7	63	5	3	5	253	77	788
1	4	0	11	2	25	4	1	2	26	9	78	5	4	0	130	35	302
2	0	0	5	<0.5	13	4	2	0	22	7	67	5	4	1	172	43	486
2	0	1	7	1	17	4	2	1	26	9	78	5	4	2	221	57	698
2	0	2	9	2	21	4	2	2	32	11	91	5	4	3	278	90	849
2	0	3	12	3	28	4	3	0	27	9	80	5	4	4	345	117	999
2	1	0	7	1	17	4	3	1	33	11	93	5	4	5	426	145	1161
2	1	1	9	2	21	4	3	2	39	13	106	5	5	0	240	68	754
2	1	2	12	3	28	4	4	0	34	12	96	5	5	1	348	118	1005
2	2	0	9	2	21	4	4	1	40	14	108	5	5	2	542	180	1405
2	2	1	12	3	28	4	5	0	41	14	110	5	5	3	920	210	3000
2	2	2	14	4	34	4	5	1	48	16	124	5	5	4	1600	350	5300
2	3	0	12	3	28							5	5	5	>1600	800	∞
2	3	1	14	4	34												
2	4	0	15	4	37												

* Number of positive tubes in five tested.

Coliform Standards

When formulating regulations, State Standards for coliform densities should be formulated in terms of "shall not exceed" a prescribed number of coliform colonies per ml., or "Coliforms, most probable number per ml.," or "per 100 ml.," rather than in terms of their absence from prescribed volumes.

Certified Milk - The American Association of Medical Milk Commissions, Inc., recognizes a standard for coliform organisms of not more than 10/ml. for Certified Milk-Raw. For

Certified Milk-Pasteurized or Pasteurized Milk made from Certified Milk, the coliform count should not exceed 10/ml. before pasteurization and 1/ml. delivered to consumers.

Table 4 MPN Estimates and Confidence Limits on the Estimates for Fermentation Tube Tests

Number of Positive Tubes out of				95% Confidence Limits Using*			
				5-10 ml, 1-1 ml 1-0.1 ml*		5 Tubes Single Dilution	
5-10 ml	1-1 ml	1-0.1 ml	MPN/100 ml	Lower	Upper	Lower	Upper
5	1	1	>240	88	-		
2	1	0	240	12	3700		-
5	0	1	96	12	370		
5	0	0	38	6.4	330		
5			> 16			8	∞
4	1	0	21	6.0	53		
4	0	1	20	5.9	48		
4	0	0	15	3.3	46		
4			16			3.3	52.9
3	1	0	12	3.1	30		
3	0	0	8.8	1.6	29		
3			9.2	1.6		1.6	29.5
2	1	0	7.9	1.5	19		
2	0	0	5	0.54	19		
2			5.1			0.54	19.2
1	1	0	4.4	0.52	14		
1	0	0	2.2	0.05	13		
1			2.2			0.05	12.6
0	1	0	2	0.05	13		
0	0	0	< 2.0	0.05	5.9		
0			< 2.2			<0.05	6

* This includes only 15 of 24 possible combinations of positive tubes. The other nine are inherently unlikely to occur with any degree of frequency. If they occur in more than 1% of tests, it is an indication of faulty technic or that assumptions underlying the MPN estimate are not being fulfilled.

Raw milk to be pasteurized - Coliform density standards for raw milk to be pasteurized do not appear to be widely used in North America, but increased attention is being given to their possible significance.

Pasteurized milk and cream - A standard proposed for wide use prescribes that coliform counts shall not exceed 10/ml. in delivery containers. This is a lenient standard which may be justified initially, but it should be made more stringent as soon as practicable.

Cultured milks - Since some pathogens may grow at temperatures used in the commercial preparation of cultured milks or may not be destroyed at the low pH of certain products, it is desirable that all cultured milks have as low a coliform density as possible. Coliform tests should be made within 48 hr. after pasteurization, since coliform counts may decrease due to the influence of pH and time.

Special flavored milks - Coliform densities in special flavored milks should not exceed those commonly accepted for properly pasteurized unflavored milks. Whenever such flavored milk contains carbohydrates other than lactose, and positive coliform tests are obtained, the presence of lactose fermenters should be verified by inoculating secondary fermentation tubes or completed tests should be performed.

Dry milk - United States standards for "extra grade" dry whole milk and nonfat dry milk have a limit for bacterial estimate, but do not have a coliform requirement. However, the recommended Sanitation Ordinance and Code for Dry Milk Products used in Grade A pasteurized milk products requires that coliform counts not exceed 90/g.

Butter - Butter made by sanitary methods should contain no more than 10 coliforms per g.

Cottage cheese - A standard of not more than 10/g. is applicable to cottage cheese less than 24 hr. old.

Infant-feeding formulas - Some state regulations require that baby-feeding formulas prepared in hospital nurseries be heat-treated before being used and that members of the coliform group shall be absent (and that the Standard Plate Count shall be less than 25 organisms per ml.), as determined by bacteriological examinations made at least once a week. Greater sensitivity can be obtained by examining greater volumes more frequently.

Reduction Methods

The methylene blue reduction method indirectly measures bacterial densities in milk and cream in terms of the time interval required, after starting incubation, for a dye-milk mixture with a characteristic blue color to become white. Different "methylene blue reduction time" intervals permit rapid grouping of samples into classes or grades. The method depends upon the ability of bacteria in milk, when incubation is started, to grow and to utilize oxygen dissolved therein, which in turn lowers the oxidation-reduction potential in the mixture. To measure this bacterial activity and to demonstrate visibly the rate of oxygen utilization, a solution of methylene blue thiocyanate, an oxidation-reduction indicator which produces initially a blue color in the mixture (concentration about 1:250,000), is added. The mixture is incubated at 36° 1° C. to hasten oxygen utilization and to shorten the required period of observation. Certified tablets of proper strength for preparation of dye solutions are available commercially.

In general, reduction time is inversely proportional to the bacterial content of the sample when incubation starts. Numerous comparisons of reduction times with estimates of bacterial populations by the agar plate method as well as with other tests have demonstrated this general relationship.

The method is used to grade raw milk, especially for manufacturing purposes. The small amount of equipment and materials and the simplicity of the method permit testing several hundred samples simultaneously. Since it combines speed and adaptability with rapid detection of poor-quality products, this test may be used in milk plants, receiving stations, condensing plants, cheese factories and similar establishments for rapid grading of incoming milk

supplies. Despite these advantages, the method reveals little or no information about any probable cause(s) of objectionable counts.

Because decolorization of methylene blue is influenced by metabolic activities of each bacterium, and because relatively large amounts of milk are used, reduction times are less affected by uneven distribution of bacteria than are numerical estimates of bacterial colonies or clumps. Since unclean utensils usually introduce large clumps of bacteria into milk, and since reduction time depends chiefly on reducing activities of individual cells whether alone or in masses, this method often measures actual degrees of contamination more satisfactorily than either the agar plate or microscopic methods. However, milks containing equivalent number of bacteria may reduce at different rates, depending upon prevailing growth phase of bacteria at time of testing and upon types of bacteria present. Bacteria in poorly cooled milk usually are growing more actively than those in well-cooled milk, in which case their rate of oxygen consumption during the first hour of incubation will be correspondingly greater. Reduction-type methods, therefore, will reflect the poor qualities of improperly cooled milk.

Objections have been raised to the application of the methylene blue reduction test in grading higher quality milks. The modified test presently used, however, attempts to meet some of these objections by keeping the bacteria and fat globules more uniformly distributed throughout the mixture. Nevertheless, if good sanitary control be maintained and bacterial content be low, the reduction test is progressively less applicable and results obtained by other methods are more meaningful.

Interpreting and Reporting Reduction Times

Application of the grading principle permits (1) classifying samples into two or more major groups, according to appreciable differences in bacterial quality, and (2) using descriptive grading terms to indicate whether or not the product be "acceptable". When reduction times are less than permitted by regulations, appropriate grading terms clearly indicating lack of compliance should be used. Under no circumstances should results be reported in terms of bacterial numbers.

Although colostrum, mastitis milk, and milk from cows far advanced in lactation may have shorter reduction times than normally would be expected from their bacterial content, the influence of such abnormal milk in mixed herd milk is practically eliminated by dilution with normal milk. Because reduction times of very poor quality milk may be lengthened materially by the incorporation of oxygen, caution should be exercised in differentiating between milks reducing in less than 1 hr. For routine control work, results should be recorded at hourly intervals.

Standards

Some state regulations provide for the grading of manufacturing milk by the methylene blue test. However, the reduction time limits used are not uniform. The sanitary codes of two dairy industry product groups recommend the separation of milk into four classes based on reduction time limits of 1, 2 1/2 and 4 1/2 hr. Proposed USDA standards for manufacturing milk provide for three classifications determined on the basis of 2 1/2 and 4 1/2 hour limits.

Resazurin Reduction Method. As milk improves in quality, testing of raw samples using the methylene blue reduction method requires incubation for inconveniently long periods. To provide comparable information in less time, resazurin, another oxidation-reduction indicator has been used as a substitute for methylene blue in the reduction test.

Resazurin possesses a high tinctorial value, imparting to fresh milk a characteristic blue color. Reduction of dye is indicated by gradual color change through various shades of purple and mauve to full pink, at which point the resazurin apparently has been completely changed to resorufin. In milk this stage of reduction is irreversible. The second stage, consisting of further reduction of resorufin to dihydroresorufin and characterized by a fading of the pink color, is reversible. Reduction of dye from the original blue to pink appears to be more independent of both oxygen content and Eh (oxidation-reduction potential) than does the change from pink to white.

Two tests have come into rather wide use. The "triple reading test" measures the time required (up to 3 hr.) to obtain dye reduction to a prescribed color end point. In the "one hour test" the degree of color change is determined after one hour incubation.

As does the methylene blue reduction test, this method requires relatively little equipment and can be used by reasonably careful workers with normal color vision. In addition to furnishing indirect information promptly concerning bacterial content and/or activity, resazurin is sensitive to reducing action of leucocytes or substances associated therewith. This sensitivity to "abnormal" milk (caused by mastitis, recent calving, late lactation, etc.) is regarded as advantageous by most workers. Inherent limitations of this method when applied routinely to milk supplies are similar to those noted for the methylene blue reduction test, although results seem to be less affected by residual antibiotics in milk.

Application of the grading principle permits (1) classifying samples into two or more major groups according to appreciable differences in quality and (2) using descriptive grading terms to indicate whether or not products be "acceptable". When reduction times are less than those permitted by regulations, use is made of appropriate grading terms which unmistakably indicate lack of compliance. Under no circumstances should results be reported in terms of bacterial numbers.

The "triple reading test," because of the longer incubation period, has some definite advantage over the "one hour test". Some well-cooled milks containing many dormant bacteria and other milks containing large numbers of leucocytes may show little color change during the first hour of incubation. Such milks may be missed by the "one hour test" but often are detected by further incubation.

The "triple reading test," requiring 3 hr., is comparable to the methylene blue reduction test in its agreement with the Standard Plate Count. The end point is reached in about one-half the time required for the reduction of methylene blue.

The original "tripled reading test" provided for color observations and inversion of tubes at the end of three successive hourly incubation intervals and classification of milk by results of the three hourly readings. Some presently used raw milk classification schemes are based on somewhat different reading times.

The proposed USDA standards for manufacturing raw milk provide for three grades established by reduction time limits of 1 1/2 and 2 1/4 hours. The sanitary codes of two dairy industry product groups include four grades of raw milk based on reduction times of 3/4, 1 1/2 and 2 1/4 hr. All these time intervals represent the time required to reach the "triple reading test" color standard of 5P7/4. For the "triple reading test," the single color standard, 5P 7/4, should be used.

The "one hour test" is also recognized in the sanitary codes of the two dairy industry groups. Four classes of milk are established on the basis of purple, lavender, pink, and decolorized end points after 1 hr. incubation. For the "one hour test," use color grades consisting of four color standards: 5 PB 7/4, 10 PB 7/5, 5 P 7/4, and 10 P 7/8.

The reductase test depends on the presence of the enzyme reductase in the milk. In a general way, the amount of reductase correlates with the number of bacteria and the age and cleanliness of the milk. It is a crude index of the general sanitary condition under which the milk was handled. The reductase in milk appears to be of bacterial origin. It has the property of decolorizing methylene blue by reducing it. The reduction time of the methylene blue depends on the oxygen consuming ability of the microorganisms which are alive and growing during the period of incubation. If no oxygen from the air be allowed to enter the tube, the oxygen consumed by the microorganisms is derived from the reduction of the methylene blue by the reductase. Therefore the introduction of oxygen into the test tube will vitiate the result of the test. Thus the reduction depends partly on (1) the availability of free oxygen from the air, (2) the oxygen consuming ability of the bacteria, (3) the production of reducing substances by the organism, (4) the presence of a natural reducing system in the milk itself. If the rate of reduction of the methylene blue depends partly on the number of organisms and partly on their metabolic activity, the test affords a very good index of both the bacterial cleanliness of

the milk, and its keeping quality. The chief value of this test lies in affording a fairly rapid means of assessing the general hygienic quality of raw milk.

The limitations of the methylene blue reduction test for estimating the sanitary quality of milk are:

1) Does not take into consideration the action of the psychrophilic and the thermophilic organisms.

2) The reducing activity lessens as time proceeds, therefore 10 hours should be the longest reduction time recorded.

3) Seasons affect the results of this method; the reduction time is shorter in summer than in winter.

4) Varying amounts of cream will effect the reduction time by bacteria being swept out of the milk into the cream layer by the rising butter fat.

5) Different species of bacteria vary the oxidation-reduction potentials of the milk, presumably because of differing oxygen consumption rates.

6) Not useful for pasteurized milk.

7) Does not indicate the variations from normal milk which might be caused by mastitis, colostrum, or lactation, although there is a tendency for the reduction time to decrease in these conditions.

Comparison of the Reductase Test and the Plate Count:

1) There is probably not much difference in the expense of doing a reductase test than a plate count.

2) The reductase test gives no specific information about bacterial content, but in a general sense it does give good indications as to the quality of raw milk, i.e. its degree of contamination and its keeping quality. The plate count does give specific information of the bacterial content if one wishes to carry out a complete procedure.

3) It takes more skill to perform a plate count than a reductase test. The reductase test is simple enough for any farmer or dairyman to perform; the plate count requires some laboratory training.

4) Although the plate count may give information about certain types or organisms, it is indeed limited in the ability to give even approximate accurate figures as to multitude of bacteria. Therefore the reductase test which gives an indication of the dynamic bacterial activity in the milk is as satisfactory as the plate count for raw milk in giving quantitative values. There are many microorganisms which will not grow on the agar plate, but will be active in the reductase test.

5) For pasteurized milk,the plate count is used in preference to the reductase test. Both are inadequate, since thermophiles will not grow efficiently on agar at 32° C. ± 1° C., whereas the dynamic activity of these bacteria is not indicated in the reductase test at 36° C. ± 1° C.

6) In many ways the two tests supplement one another.

7) The reductase test is not good for testing pasteurized milk because bacteria grow so much quicker in pasteurized milk than in raw milk.

8) Reductase test is not affected by clumping of bacteria, the plate count is.

9) Reductase test is believed to be influenced less by the uneven distribution of bacteria in milk than the agar (or microscopic) counts.

10) Some bacteria that reduce dye may fail to develop colonies.

11) The reducing activities of bacterial cells are not diminished by clumping, whereas plate counts are reduced by clumping.

12) The presence of inhibitory substances such as antibiotic residual from mastitis therapy may interfere with bacterial activity in the reduction tests.

Thermoduric Bacteria

Thermoduric bacteria are those which survive but do not grow at pasteurizing temperatures. While including some sporeforming bacteria, they are largely nonsporeforming, heat-resistant types that develop on surfaces of ineffectively cleansed milk handling equipment. Control of thermoduric species is an operational problem involving both dairy farms and milk plants. These bacteria may contribute significantly toward high Standard Plate Counts on pasteurized milk and other fluid milk products.

To test the milk for thermoduric bacteria, 5 ml. of the thoroughly mixed raw milk sample is transferred to a screwcapped test tube, being careful to avoid contaminating the lip and upper portions of tube with raw milk. While assembling a series of tubes for laboratory pasteurization, the tubes are held in ice water at 0-5° C. A pilot tube containing 5 ml. of milk with thermometer inserted therein is placed in the rack during the preliminary holding period in the ice bath as well as during pasteurization. The rack of tubes is placed in pasteurizing bath at 62.8° C. The tubes should be immersed so that the water line is approximately 1 1/2 inch above the level of the milk in the tubes. The temperature of the milk should reach at least 62.3° C. within 5 min.

When the temperature in the pilot tube reaches 62.3° C., the timing of the holding period is started and the sample is exposed to the pasteurizing temperature for 30 min. At the end of the 30 minute holding period, the rack of tubes is immediately placed in an ice water bath and the tubes are cooled to 10° C. (50° F.) or below, as indicated by the thermometer in the pilot tube. The Laboratory Pasteurization Count (LPC) is determined by the agar plate method. For unofficial test purposes, simplified viable count methods may be useful.

The results are reported as "Laboratory Pasteurization Count per ml." (LPC/ml.). Where one of the simplified methods is used, the appropriate designation is added to the report count to identify the method.

Thermophilic Bacteria

Thermophilic bacteria can cause bacteriological problems in milk which undergoes any one of numerous heat treatments, including pasteurization. Definitively, thermophilic bacteria are those which grow at 55° C. Many of these bacteria are facultative and can grow at 37° C. or lower. Usually thermophiles are sporeforming bacilli. Thermophilic bacteria probably enter milk from various sources on the producing farm, although their numbers in raw milk at this point usually are very small. However, when milk is held at high temperatures for long periods of time, thermophiles develop quickly into very large populations. Large rod-shaped bacteria that are strongly stained in milk films prepared from pasteurized milk according to the procedure for the Direct Microscopic Count are probably thermophiles. The presence of thermophiles is proven, however, by the ability of the organisms to form colonies when agar plates prepared from the samples are incubated at 55° C. ± 1° C.

Dilutions and plates are prepared for testing for thermophiles as described for the Standard Plate Count, except that 15-18 ml. of agar are used and plates are incubated for 48 hr. at 55° C. ± 1° C. After determining the colony count, the results are reported as "Thermophilic Bacterial Count per ml." (or per g.), or TBC/ml. (or /g.).

Psychrophilic Bacteria

Psychrophilic bacteria are those which are capable of relatively rapid growth at low temperatures, commonly within the range of 2-10° C. (35-50° F.). The importance of psychrophiles has increased with extended refrigerated storage of raw and pasteurized milk and other dairy products. These bacteria are not pathogenic, but their growth in dairy products can cause a variety of off-flavors, including fruity, putrid, and rancid, as well as physical changes. At present, the only method for selective enumeration of psychrophiles is by low temperature incubation of plates. Several temperature-time combinations for incubation of plates have been suggested. In the interest of reasonable selectivity and uniformity of method, a single combination of temperature and time for incubation has been selected for the enumeration of this group of bacteria. Recently it was reported that some strains of psychrophiles, when present in large numbers, may survive pasteurization. However, practical experience indicates that in commercial pasteurization, extremely few psychrophiles, if any, escape destruction.

Dilutions of the product and the plates are prepared for testing for psychrophiles in the same manner as described for the Standard Plate Count except that the plates are incubated at 7° C. ± 1° C. for 10 days. Special care is taken that melted medium is cooled to at least 45° C. before pouring plates to prevent destruction of some psychrophilic species. At temperatures above 7° C. other organisms may grow, possibly yielding misleading results.

After determining the colony count, the results are reported as "Psychrophilic Bacterial

Count per ml." (or per g.), or PBC/ml. (or /g.).

Detection of Inhibitory Substances in Milk

The need for qualitative and quantitative tests for the presence of antimicrobial agents in milk has been recognized for some time. As early as 1944-45, the filter paper disc method for antibiotic assays was developed. Working concurrently and independently, several groups of investigators studied its application and applied the disc method to milk in 1950-51.

The disc assay method herein described with some modifications has been applied generally to determine the presence of residual antibiotics, including penicillin. With due care and the use of suitable controls, reasonably reliable assays can be made. The use of previously standardized materials should provide uniform conditions for testing.

Plates are examined for zones of inhibition surrounding test discs and, if desired, the diameters of zones are compared. To determine the amount of penicillin in samples, compare the diameters with those obtained by using standard reference discs. Such reference discs are prepared by moistening each with sterile water (do not dip into water), and otherwise subject them to identical conditions of preparation and incubation observed for test samples. Note. — On freshly poured agar plates there is sufficient surface moisture to saturate discs.

Identity Test for Penicillin

1. To determine if inhibition results from penicillin, penicillinase-impregnated discs treated with test sample as directed above are used. If no zone of inhibition appears around penicillinase disc, but one surrounds the disc containing the test sample, penicillin is present. If a zone of inhibition surrounds both discs, an inhibitor other than penicillin may be present.

When the edge of a penicillinase-impregnated disc is touched to the surface of milk samples, a slight dilution of the penicillinase occurs by leaching of the enzyme into the milk. To prevent possible misinterpretations caused by such leaching, place a disc dipped in milk and one dipped in penicillinase (or one commercially prepared with penicillinase) near each other on a plate. If the inhibitor in the milk be penicillin, a characteristic neutralization zone appears at the juncture.

2. Alternatively, add 0.5 ml. of penicillinase concentrate to a 5 ml. aliquot of the milk sample and shake well. Prepare three unimpregnated blank discs from the penicillinase-treated sample and three unimpregnated blank discs from an untreated aliquot of the sample. All six discs are placed on one plate and the agar inoculated with spores is prepared and poured into the petri dish.

A zone around the discs dipped in untreated milk, but no zone around the discs dipped in penicillinase-treated milk, is a positive test for penicillin.

Test for Bacterial Spores. Since spore bearing bacteria in milk are derived originally from cow manure, dust, or dirty utensils, the presence of these organisms indicates contamination from the above sources. Certified milk usually shows no evidence of anaerobic spore-bearing bacteria except in occasional tubes. The cleanliness of certified milk is checked by plate count, microscopic test, methylene blue reduction test, sediment test, and coliform test, but the total count of bacteria fails to indicate the strictness of cleanliness because the numbers present may be due largely to multiplication, or to other factors than manure. The coliform test fails because the organisms may multiply in milk (doubling their numbers in 20 minutes under favorable conditions) and therefore may not indicate the degree of manurial contamination. Neither the sediment test nor the microscopic test is an adequate index of spore-forming bacteria in milk. The spore test overcomes all the above limitations for estimating cleanliness in certified and pasteurized milk. The anaerobic spore-bearing bacteria do not multiply under the conditions for keeping milk. They are not destroyed by pasteurization and they cannot be filtered out by any ordinary filtering device. Thus the spore test is not only superior for raw milk as a detector for manurial contamination, but also for pasteurized milk.

The technique of the spore test is as follows: 10 c.c. of milk is placed into a tube containing 2 c.c. of sterile vaseline. This is heated to 80° C. for 15 minutes. In this way the non-spore

bearing bacteria are destroyed, all gas (oxygen) is driven from the milk, and the melted vaseline rises to the surface forming an air tight seal over the milk (anaerobes will grow only in absence of molecular oxygen). Thus the anaerobes can grow if incubated for 72 hours at 37° C. The formation of gas, coagulation or digestion of the milk means that the anaerobes are present and growing. The presence of gas is detected by the pushing up of the vaseline seal.

Phosphatase Test. The phosphatase test depends upon the fact that raw cow's milk contains an enzyme called phosphatase which is sensitive to heating. The remarkable character of this enzyme is that its destruction point corresponds so very closely with the standard time and temperature designated for pasteurization. When heated at 61.6° C. (143° F.) for 30 minutes, or 71.6° C. (161° F.) for 15 seconds, about 96% of the enzyme is destroyed. At 62.8° C. (145° F.) for 30 minutes, it is completely destroyed. The discovery of the phosphatase test marked a milestone in the development of milk sanitation. So sensitive is the phosphatase enzyme to the standard temperature-time action of pasteurization that the enzyme can be detected when the milk is held at 61.6° C. (143° F.) for 25 minutes, 60.8° C. (141 1/2° F.) for 30 minutes, or if as little as 1/10 of 1% of raw milk be added to pasteurized milk.

The technique of the phosphatase test is concerned with the procedure of detecting the presence or absence of traces of phosphatase after milk has been exposed to the process of pasteurization. The rationale of the procedure is based on the fact that phosphatase is able to liberate phenol from any phosphoric-phenyl ester with which it comes into contact by hydrolyzing the phosphoric-phenyl radical to produce free phosphoric acid and free phenol. When milk is pasteurized, the amount of phosphatase remaining undestroyed in the milk is scarcely enough to cause a trace of phenol to be liberated and detected. When more than this trace is liberated it is an indication that there is more phosphatase in the milk than would be expected if the milk were adequately pasteurized. The phenol is detected by various methods of discoloration, and therefore the final step in the test is to compare the end-product of the test with some form of color standards.

Certain strains of bacteria such as the thermophile Lactobacillus enzymothermophilus elaborates a phosphatase enzyme and causes thoroughly pasteurized milk to show a "false positive" phosphatase test. This may explain many positive phosphatase tests attributed to manual and mechanical defects in a dairy plant. The rapid phosphatase test is done as follows:

Mix 5 ml. of buffered substrate and 0.5 ml. of milk sample. Shake briefly. Incubate for 15 minutes in a water bath at 39° C. - 41° C. Discontinue incubation and add 6 drops of BQC solution. Immediately shake thoroughly and allow to stand for 5 minutes. Appearance of blue color indicates underpasteurization. For greater sensitivity, add 2 ml. neutral n-butyl alcohol. Extract indophenol by completely inverting the tube 10 times, pausing after each 180° arc to allow bubbles to break and alcohol to separate. Rapid inversion will cause an emulsion but proper extraction will produce a clear supernatant alcohol layer about 3/4 inch deep. Compare with color standards for field test using recommended filter. Increasing the incubation time to 30 minutes at 41° C. will increase the sensitivity of the test so that it approaches the sensitivity of the laboratory test.

In comparing the clear supernatant alcohol layer with the color standards, an opal double-fluxed glass or sheet of Phastacele (No. C-1605 HH. 0.015 inch thick) should be used as a light filter. Readings can be made in natural or artificial light.

The color standards used for this test are prepared as follows:

1. The standard indicating 2 units: Combine 0.4 ml. red color solution, 0.5 ml. yellow color solution, and 1.5 ml. blue color solution. Dilute this with water to make up 5 ml.
2. The standard indicating 5 units: Combine 0.2 ml. red color solution, 0.5 ml. yellow color solution, and 2.2 ml. blue color solution. Dilute this with water to make up 5 ml.

The color solutions are made up as recommended in Standard Methods for Examination for Dairy Products.

All equipment should be thoroughly washed and rinsed before re-use. The use of phenolic resin bottle closures should be avoided. The BQC solution and buffer substrate solution decom-

pose with age, therefore they should be stored under refrigeration or prepared shortly before use. As a check against the sensitivity of the BQC reagent, include a 1.0% raw milk control (99% boiled milk 1.0% raw milk) in each series of phosphatase tests. In interpreting this field test, a value equal to or greater than 2 units generally indicates underpasteurization:

Interpretation of the regular laboratory phosphatase test:

1. Properly pasteurized milk will be gray or brown.
2. Properly pasteurized cream will be gray or white.
3. Raw milk or cream will be an intense blue. Intensity of color is proportional to degree of underpasteurization.
4. The test will detect 0.1% raw milk mixed with pasteurized milk, or one degree below standard temperature, or 5 minutes under heating during pasteurization.
5. Any blue color the intensity of which is less than 2 units is considered satisfactory pasteurization.

Chapter XVII

Market-Milk Control

Although milk is one of the most nutritious of foods, it is also one of the most hazardous to consume if its handling before consumption be unsanitary. One of the reasons for the decline in death rates from such communicable diseases in the United States as infant diarrheas, dysentery, typhoid fever, scarlet fever, and tuberculosis is because the sanitarians work in milk control has been so effective. The sanitarian's success has been due not only to the police power which has aided him in enforcing regulations, but also to his ability to serve as an educational consultant to the farmer and the milk plant operator. The educational aspect of his work becomes more and more important as the consumption of milk increases, the educational level of the producers increases, and the mechanization of the milk industry becomes greater. It therefore becomes necessary that the sanitarian understand in greater detail the bacteriology of milk, its physical and chemical properties as these relate to the various processes in production, the nutrition of milk cows, the various types of milk cows, the economic aspects of milk production, the mechanical techniques related to the utensils, containers, and equipment, and many other phases of knowledge relating to milk. The farmer and plant operator expect the sanitarian to know these things because they do not separate the sanitary techniques which they must adhere to from the economics of their work. To them, it costs more to be sanitary and the cost of operations must pay economic dividends. If the sanitarian be responsible for inspecting the dairy farm, the milk collecting stations and the processing plants, how can such inspection have any validity unless the sanitarian knows rather precisely what he is inspecting. Milk production, like potable water production, goes on in every rural and urban community in our country. The sanitarian's knowledge must extend to every process of such production. He does not design the mechanical equipment but he must understand how it works and how to test the adequacy of such equipment. He does not do all the laboratory tests relating to milk control but he must be able to do the simpler field tests and to understand the meaning of those tests performed in the laboratory. He does not diagnose diseases in cattle or perform tuberculin and Bang's disease tests, but he must be able to understand when to recommend the services of the veterinarian and to work closely with him in these matters. The role of the sanitarian in milk control has become a most exacting job. He must know a great deal about many things in order to detect a hazard, and he must realize when the services of the engineer, bacteriologist, chemist, agriculturist, or veterinarian must be enlisted. The more knowledge the sanitarian has about every aspect of milk control, the more will he be able to understand his function in this field and also his limitations. Milk ordinances usually place the responsibility of milk control upon the health officer, but the health officer usually relies on the training and ability of his sanitarians to do the actual job efficiently and effectively.

Production and Consumption

Milk is an important dietary product because of the large quantities of essential materials of nutritional value which are concentrated in it. For this reason it is one of the cheapest foods considered from a nutritional point of view.

Minerals. Milk contains significant quantities of calcium, phosphorous, potassium, chlorine, sodium, sulphur and magnesium. It contains minute quantities of iron, iodine, copper, manganese, and zinc.

The best milk is produced by healthy cows. In order for cows to maintain good health they, like human beings, require adequate diets. Table 3 below shows the recommended nutrient allowances for dairy cattle from the Report of the Committee on Animal Nutrition of the National Research Council, August 1945.

Table 1. Number of Milk Cows on Farms and Total Production of Milk, United States - 1924 - 1965

Year	Milk Cows on Farms [1] (thousands)	Production of Milk per Milk Cow [2] (pounds)	Total Milk Production on Farms [2] (million pounds)
1925	21,503	4,218	90,699
1930	22,218	4,508	100,158
1935	24,187	4,184	101,205
1940	23,684	4,624	109,510
1945	25,519	4,789	122,219
1950	23,853	5,054	116,602
1955	23,462	5,240	122,945
1960	19,527	6,296	122,951
1965	17,592	7,109	125,061

1. Average number during year, heifers not freshened excluded.

2. Excludes milk sucked by calves and milk produced by cows not on farms. To convert pounds of milk to gallons, divide by 8.6.

Source: 1924-45 - compiled from Agricultural Statistics
1946-65 - compiled from Statistical Abstracts of the United States

Composition and Nutritional Value

Average Composition:

	Cow		Human	
Water	87.34	percent	87.58	percent
Fat	3.75	"	3.74	"
Sugar (lactose)	4.76	"	6.37	"
Protein - Total	3.40	"	2.01	"
Caseinogen	3.00	"	0.81	"
(Lactalbumen) (Lactoglobulin)	0.40	"	1.21	"
Minerals	0.75	"	0.30	"
Total Solid	12.66	"	12.42	"
Total Solids not fat	8.91	"	8.68	"
Specific Gravity	1.0313		1.0298	

Table 2. Dairy Products: Annual Per Capita Consumption in U. S., 1910 - 1965

Year	Milk[1] (gallons)	Butter[2] (pounds)	Cheese[3] (pounds)	Evaporated[4] Milk (pounds)	Condensed[5] Milk (pounds)	Ice[6] Cream (gallons)
1910	36.6	18.3	4.3	2.2	4.3	0.4
1915	36.7	17.2	4.1	4.5	6.2	0.9
1920	40.3	14.9	4.0	8.8	1.4	1.7
1925	39.2	18.1	4.7	11.1	2.5	2.2
1930	38.6	17.6	4.7	14.0	2.3	2.2
1935	38.0	17.6	5.3	17.1	1.5	1.8
1940	38.5	17.0	6.0	20.8	1.8	2.7
1945	46.4	10.9	6.7	24.0	2.0	4.3
1950	40.6	10.7	7.7	23.2	2.0	4.2
1955	40.6	9.0	7.9	18.9	2.0	4.9
1960	37.4	7.5	8.3	15.7	2.5	5.4
1965	35.4[7]	6.9[7]	9.5	14.0[7]	2.2[7]	5.6[7]

1. Milk and milk equivalent of cream consumed per capita.
2. These estimates include some butter used in other dairy products.
3. Except cottage, pot, and baker's cheese.
4. Whole milk and skimmed milk evaporated.
5. Sweetened and unsweetened.
6. Plus sherbet and ice milk.
7. For 1963.

Source: U. S. Food Consumption, U. S. Department of Agriculture, June 1965.

Vitamins. With the view of the nutritional value of vitamins, milk is rich in vitamin A; fairly good in thiamin and niacin, and rich in riboflavin; less dependable in vitamin C (ascorbic acid); relatively poor in vitamin D; fair to good in vitamin E; and rich in vitamin G. Most vitamins in milk are stable and heat resistant except vitamin C, which is unstable and destroyed by heating. The vitamins A and D are found in the milk fat and are therefore called fat-soluble. The others are found in the non-fat fluid of the milk. The vitamin D content appears to depend on the prevalence of sunshine and on the intake of this vitamin by the cow, therefore milk tends to contain more of this vitamin in summer than in winter. Vitamin C content also appears to be affected by the seasons; it is higher in the seasons when the pastures are good. It is interesting to note that cows do not need vitamins B and C in their diets because they are capable of synthesizing these vitamins in their own bodies, therefore high priced foods fortified with these two vitamins are

unnecessary.

An average quart of cow milk contains the following nutritional values: 675 calories, 34 grams of protein, 1.15 grams of calcium, .91 grams of phosphorus, .001 grams of iron, 1.4 grams of potassium, .12 grams of magnesium, 1500 international units of vitamin A, .0004 grams of vitamin B_1 (thiamin), .0017 - .0022 grams of vitamin B_2 (riboflavin), .001 grams of niacin, .009 - .023 grams of vitamin C (ascorbic acid), and 7-26 international units of vitamin D.

Table 3. Recommended Nutrient Allowances for Dairy Cattle (Committee on Animal Nutrition. National Research Council)

Weight of Animal	Expected Gain		Daily Allowance Per Animal					
	Jersey	Holstein	Digestible Protein	Total Digestible Nutrient	Ca	P	Carotene	Vitamin D
Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Gm.	Gm.	Mg.	I. U.
Growth:								
50	0.5	...	.30	1.0	4	3	(2)*	150
100	1.0	0.8	.45	2.0	8	6	6	300
150	1.3	1.4	.60	3.0	12	8	10	450
200	1.4	1.6	.70	4.0	13	9	12	600
400	1.2	1.8	.80	6.5	14	11	25	1200
600	0.8	1.4	.85	8.5	15	12	35	....
800	1.1	1.2	.90	10.0	15	12	45	....
1000	...	1.3	.95	11.0	14	12	60	....
1200	...	1.2	1.00	12.0	12	12	70	....
Maintenance								
700			.45	6.0	7	7	40	....
1000			.60	8.0	10	10	60	....
1200			.70	9.5	12	12	70	....
1400			.80	11.0	14	14	80	....
Pregnancy (Per 1000 lbs.) (Last 6 to 12 weeks)			1.2	14.0	22	17	90	....
Lactation (per lb. milk)								
3.0% fat			.040	.28	1	.7	...	....
4.0% fat			.045	.32	1	.7	...	....
5.0% fat			.050	.37	1	.7	...	....
6.0% fat			.055	.42	1	.7	...	....

*Calves should receive colostrum the first few days after birth, as a source of Vitamin A and other essential factors.

Enzymes, etc. Milk also contains enzymes, antibodies, epithelial and white blood cells (leucocytes), gases such as carbon dioxide, oxygen, and nitrogen, and acids and other substances in minute quantities.

Drugs and poisons consumed by cows are excreted in the milk, therefore cows producing certified milk are allowed to graze only in pastures free from weeds that may affect the cows or milk deleteriously.

Colostrum differs markedly from milk in appearance, composition, quality and function. It contains many antibodies. Calves do not survive well without it because they may succumb to intestinal and kidney infections. Colostrum milk is reddish yellow, strong in odor, bitter in taste, and has an increase of the proteins (globulin, albumin, casein) and ash, and a decrease of lactose.

Table 4.

FOOD AND NUTRITION BOARD, NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH COUNCIL
RECOMMENDED DAILY DIETARY ALLOWANCES,[a] REVISED 1968
Designed for the maintenance of good nutrition of practically all healthy people in U.S.A.

	AGE[b] (years)		WEIGHT		HEIGHT				FAT-SOLUBLE VITAMINS			WATER-SOLUBLE VITAMINS							MINERALS				
	From	Up to	(kg)	(lbs)	cm	(in.)	kcal	PROTEIN (gm)	VITAMIN A ACTIVITY (IU)	VITAMIN D (IU)	VITAMIN E ACTIVITY (IU)	ASCORBIC ACID (mg)	FOLACIN[c] (mg)	NIACIN (mg equiv)[d]	RIBOFLAVIN (mg)	THIAMIN (mg)	VITAMIN B_6 (mg)	VITAMIN B_{12} (µg)	CALCIUM (g)	PHOSPHORUS (g)	IODINE (µg)	IRON (mg)	MAGNESIUM (mg)
Infants	0	1/6	4	9	55	22	kg X 120	kg X 2.2	1,500	400	5	35	0.05	5	0.4	0.2	0.2	1.0	0.4	0.2	25	6	40
	1/6	1/2	7	15	63	25	kg X 110	kg X 2.0	1,500	400	5	35	0.05	7	0.5	0.4	0.3	1.5	0.5	0.4	40	10	60
	1/2	1	9	20	72	28	kg X 100	kg X 1.8	1,500	400	5	35	0.1	8	0.6	0.5	0.4	2.0	0.6	0.5	45	15	70
Children	1	2	12	26	81	32	1,100	25	2,000	400	10	40	0.1	8	0.6	0.6	0.5	2.0	0.7	0.7	55	15	100
	2	3	14	31	91	36	1,250	25	2,000	400	10	40	0.2	8	0.7	0.6	0.6	2.5	0.8	0.8	60	15	150
	3	4	16	35	100	39	1,400	30	2,500	400	10	40	0.2	9	0.8	0.7	0.7	3	0.8	0.8	70	10	200
	4	6	19	42	110	43	1,600	30	2,500	400	10	40	0.2	11	0.9	0.8	0.9	4	0.8	0.8	80	10	200
	6	8	23	51	121	48	2,000	35	3,500	400	15	40	0.2	13	1.1	1.0	1.0	4	0.9	0.9	100	10	250
	8	10	28	62	131	52	2,200	40	3,500	400	15	40	0.3	15	1.2	1.1	1.2	5	1.0	1.0	110	10	250
Males	10	12	35	77	140	55	2,500	45	4,500	400	20	40	0.4	17	1.3	1.3	1.4	5	1.2	1.2	125	10	300
	12	14	43	95	151	59	2,700	50	5,000	400	20	45	0.4	18	1.4	1.4	1.6	5	1.4	1.4	135	18	350
	14	18	59	130	170	67	3,000	60	5,000	400	25	55	0.4	20	1.5	1.5	1.8	5	1.4	1.4	150	18	400
	18	22	67	147	175	69	2,800	60	5,000	400	30	60	0.4	18	1.6	1.4	2.0	5	0.8	0.8	140	10	400
	22	35	70	154	175	69	2,800	65	5,000	-	30	60	0.4	18	1.7	1.4	2.0	5	0.8	0.8	140	10	350
	35	55	70	154	173	68	2,600	65	5,000	-	30	60	0.4	17	1.7	1.3	2.0	5	0.8	0.8	125	10	350
	55	75+	70	154	171	67	2,400	65	5,000	-	30	60	0.4	14	1.7	1.2	2.0	6	0.8	0.8	110	10	350
Females	10	12	35	77	142	56	2,250	50	4,500	400	20	40	0.4	15	1.3	1.1	1.4	5	1.2	1.2	110	18	300
	12	14	44	97	154	61	2,300	50	5,000	400	20	45	0.4	15	1.4	1.2	1.6	5	1.3	1.3	115	18	350
	14	16	52	114	157	62	2,400	55	5,000	400	25	50	0.4	16	1.4	1.2	1.8	5	1.3	1.3	120	18	350
	16	18	54	119	160	63	2,300	55	5,000	400	25	50	0.4	15	1.5	1.2	2.0	5	1.3	1.3	115	18	350
	18	22	58	128	163	64	2,000	55	5,000	400	25	55	0.4	13	1.5	1.0	2.0	5	0.8	0.8	100	18	350
	22	35	58	128	163	64	2,000	55	5,000	-	25	55	0.4	13	1.5	1.0	2.0	5	0.8	0.8	100	18	300
	35	55	58	128	160	63	1,850	55	5,000	-	25	55	0.4	13	1.5	1.0	2.0	5	0.8	0.8	90	18	300
	55	75+	58	128	157	62	1,700	55	5,000	-	25	55	0.4	13	1.5	1.0	2.0	6	0.8	0.8	80	10	300
Pregnancy							+200	65	6,000	400	30	60	0.8	15	1.8	+0.1	2.5	8	+0.4	+0.4	125	18	450
Lactation							+1,000	75	8,000	400	30	60	0.5	20	2.0	+0.5	2.5	6	+0.5	+0.5	150	18	450

a The allowance levels are intended to cover individual variations among most normal persons as they live in the United States under usual environmental stresses. The recommended allowances can be attained with a variety of common foods, providing other nutrients for which human requirements have been less well defined. See text for more-detailed discussion of allowances and of nutrients not tabulated.

b Entries on lines for age range 22-35 years represent the reference man and woman at age 22. All other entries represent allowances for the midpoint of the specified age range.

c The folacin allowances refer to dietary sources as determined by Lactobacillus casei assay. Pure forms of folacin may be effective in doses less than 1/4 of the RDA.

d Niacin equivalents include dietary sources of the vitamin itself plus 1 mg equivalent for each 60 mg of dietary tryptophan.

e Assumes protein equivalent to human milk. For proteins not 100 percent utilized, factors should be increased proportionately.

Table 5. Progressive Changes of Colostrum into Milk

Time after Calving	Specific Gravity	Chlorides %	Casein %	Albumin Globulin %	Ash %	Fat %	Lactose %	Total Solids %	Coagulates on Heating
At once	1.0670	0.1525	5.08	11.34	1.01	5.10	2.19	26.99	Yes
6 hours	1.0437	0.1631	3.51	6.30	0.91	6.85	2.71	20.46	"
12 hours	1.0368	0.1560	3.00	2.96	0.89	3.80	3.71	14.53	"
1 day	1.0343	0.1560	2.76	1.48	0.86	3.40	3.98	12.77	"
1 1/2 days	1.0320	0.1595	2.77	1.03	0.84	3.55	3.97	12.22	"
2 days	1.0319	0.1489	2.63	0.99	0.83	2.80	3.97	11.46	"
3 days	1.0331	0.1365	2.70	0.97	0.84	3.10	4.37	11.86	No
4 days	1.0335	0.1347	2.68	0.82	0.83	2.80	4.72	11.85	"
5 days	1.0334	0.1312	2.68	0.87	0.85	3.75	4.76	12.67	"
7 days	1.0320	0.1134	2.42	0.69	0.84	3.45	4.96	12.13	"

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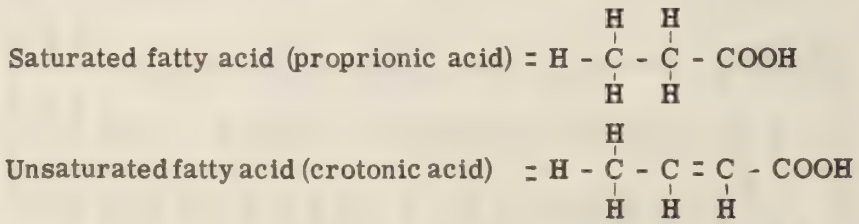
Milk from cows in heat or in gestation may cause gastrointestinal disturbance.

Milk Fat: "Richness" of milk refers to its fat content which is present in the form of relatively large fat globules. Milk fat is composed of 11 or more fatty acids. The most common fatty acids in milk fat are: butyric, caproic, caprylic, capric, lauric, myristic, palmitic, stearic, arachidic, oleic, and linoleic.

A fatty acid is an organic acid which, when in combination with glycerin, forms soap. A saturated fatty acid is one in which the carbon atoms are united with as much hydrogen as they can hold. An unsaturated fatty acid is one in which the carbon atoms are not completely saturated with as much hydrogen as they can hold;
Examples:



Of the above mentioned fatty acids in milk fat, all are saturated except oleic and linoleic acids which are unsaturated. The proportion of the various fatty acids in milk fat depend mainly on:

1) Type of Feed. Changing from winter to summer feeding causes an increase in percent of unsaturated acids, especially oleic acid, and a decrease in percent of saturated acids. Oleic acid has a low melting point, therefore the butter churning temperature must be lower in the summer than the winter. Concentrated feeds high in vegetable oils give an increase in oleic acid content of milk fat which decreases the melting point of butter. The exception to this is the use of cottonseed meal which not only increases the oleic acid but at the same time decreases the butyric acid enough to cause an increase in the melting point of butter. The addition of corn silage to cow ration produces enough butyric acid in the milk fat to decrease the melting point of butter

2) Underfeeding. When cows are underfed the volatile acids, mainly butyric, are decreased and oleic acid is increased. This relation will determine the variability of the melting point of the milk fat.

3) State of Lactation. The volatile acids, mainly butyric, gradually decrease and oleic acid gradually increases in milk fat from the beginning to the end of the lactation period.

4) Breeds. Volatile acids are higher in content in the milk fat of Jersey cows than in that of Holstein, Ayrshire, or Shorthorn. Oleic acid is greater in milk fat of Holstein and Shorthorns than in Jersey cows.

It is clear that the melting point of milk fats depends mainly on the relation between butyric and oleic acids.

Influence of Feed on Color of Milk Fat. The color of milk fat depends entirely upon the feed. Carotene, from which Vitamin A is formed, is yellow while the vitamin itself is colorless. Therefore the degree of yellowness does not indicate the vitamin A potency (this is equal to carotene plus vitamin A). Holstein cows convert more carotene to Vitamin A than Guernsey or Jersey cows, therefore the latter milk fat will usually be more yellow. Vitamin A potency of milk fat may be maintained at a high level by feeding:

1) Unbleached legume hay.
2) A. 1. virtanen silage (ensiled by addition of inorganic acid which kills bacteria and preserves vitamin A.)
3) Legume-molassas silage.

Size of Fat Globules is Influenced by:

1) Breed. Jersey and Guernsey cows produce milk fat with larger globules than Ayrshire and Holstein.
2) Lactation. As lactation period advances the size of the globules decreases.

This is important in that the smaller the globules the longer time is necessary for churning and for the cream to rise to the surface. The globules have surface membranes composed of lecithin and protein.

Factors which Influence the Fat Content of Milk.

1) Breeds which produce large quantities of milk give milk with lower fat content, and vice versa.
2) Individual heredity differences of cows cause variation in fat content of milk produced.
3) Age is important factor: from the first to about the third lactation the fat content of milk increases; for the next four or five lactations the content remains more or less constant; during subsequent lactation periods the fat content gradually decreases.
4) State of lactation influences fat content in that it is lower during the first 2 or 3 months, then gradually increases to the end of the lactation period; it may increase markedly during the last few weeks of lactation.
5) Season of year and temperature causes variation in fat content. It is highest in late fall and early winter. Fat content increases about 0. 2% for each 10^{o} decrease in temperature between 72^{o} and 27^{o}F.
6) Feed has no permanent effect on the fat content, but does affect the composition of the fat.
7) Condition of cow at parturition when good influences the milk to have a high fat during the first few days or weeks, but when condition is poor the fat content is lower.
8) Intervals between milking when irregular cause variation of fat content, the highest fat coming after the shortest interval.
9) Morning and evening milking when regular usually show no difference in fat content, but may show a slightly higher fat in the evening.
10) Stage of milking influences fat content somewhat as follows:

Foremilk - - - - - - -	1. 9%	fat - - - - - - - -	15% of milk withdrawn
Middle milk- - - - - -	2. 3%	" - - - - - - - -	58% of milk withdrawn
Stripping- - - - - - -	6. 8%	" - - - - - - - -	27% of milk withdrawn
	3. 6%		

This emphasizes the importance of complete milking.

11) Order of milking the quarters is important. If all quarters be milked simultaneously as with a milking machine, the variation of fat content of each quarter is not noticeable, but if each quarter be milked separately the first quarters milked give the highest fat content and last give the lowest fat.
12) Mating Period, or Oestrum may influence composition and yield probably because of the excitability of the cow. When the cow holds up one or more milkings the yield is less and the fat low. When the cow secretes less milk at each milking the decreased yield is accompanied by an increase fat content.
13) Excitement caused by changing milkers, fright from dogs, strange noises, and the like

cause cow to hold up milk thus decreasing yield, and also decreasing fat percent due to loss of strippings.

14) Drugs generally do not increase yield or fat.

Effect of Heat on Fat Globule. Heating to 65°C. causes fat droplets to break up and hinders the rising of the fat droplets. If heated above 63°C. for 40 minutes or longer, the formation of the cream line is noticeably retarded and the richness of the milk cannot be judged by the cream layer. When milk is atomized under 1500 pounds pressure at a temperature of 75°C., it becomes homogenized, that is, the fat droplets are broken into such small globules that they remain suspended in the milk, and the fat does not separate out on allowing the milk to stand. This process applied to cream increases its viscosity and apparent volume so that cream containing 20% milk fat may appear to have 30%. Homogenization will dispose milk to more rapid rancidification by exposing more of the fat globule surface to action of the enzyme lipase which causes a breakdown of the milk fat. If the milk be preheated to 145°F. or pasteurized before homogenization, the enzyme lipase is destroyed and rancidification is reduced.

Creaming Ability of Milk. The creaming ability of milk is influenced by heating, cooling, and agitation. These effect the size of the fat clumps. The smaller the fat clumps, the more compactly they will gather and form a shallower cream-layer volume. The larger the fat clumps, the more loosely they will pack and the deeper the layer. Fat clumping occurs most readily between 35 and 50°F. Pasteurization will restore normal creaming ability which had been harmed by agitation or pumping.

The maximum cream volumes in bottled milk may be secured if the following procedures be observed:

1) Raw milk should be cooled to 50°F., bottled immediately, and stored at 40°F. or lower.

2) Pasteurized milk should be flash-cooled to between 35 and 40°F., bottled immediately, and stored between 35 and 40°F. until delivered.

3) If the holding method of pasteurization be used, a temperature of 143°F. and a holding time of 30 minutes are most satisfactory.

4) Excessive agitation should be avoided as much as possible between 60 and 120°F., especially after pasteurization.

5) The milk should be delivered as soon as practicable after the maximum cream-layer volume has formed. Properly cooled milk shows a maximum cream-layer depth 2 to 4 hours after cooling. Thereafter the layer shrinks to its minimum in about 24 hours.

6) The milk should be kept below 50°F. during delivery.

Proteins. The three principal proteins in milk are casein, lactalbumin, and lactoglobulin. Milk proteins contain more than 20 varieties of amino acids among which are found all the essential (i.e. necessary to life) amino acids that are known. Casein is one of the most complete proteins known. It will coagulate in the presence of acid, rennet, and alcohol to form curd. Cheese making is based upon this characteristic of casein. Lactalbumin and lactoglobulin remain in the whey in solution or colloidal suspension. The latter proteins are easily coagulated by heat.

Lactalbumin coagulates partially (30%) at 160°F. Lactoglobulin coagulates completely at 161.6°F. Casein coagulates between 268° and 280°F.

Soft curds are more digestible than hard curds. The curd of milk may be soft or tough depending upon the individual cow or mammal. Mother's milk has a softer curd than cows milk. Milk with a curd tension of less than 30 grains is called soft curd, above this it is hard curd. Artificial soft curds can be produced by homogenizing milk between 100° and 104°F. at 3000 pounds pressure. Boiling also softens curds. A small amount of blood serum added to milk will soften curd. Cows with pathological conditions of the udder give milk of soft curds.

It is important to remember that due to the peculiar character of the stomach of the cow and the types of bacteria and protozoa which inhabit this stomach, the cow, with the aid of these microorganisms, is able to produce its own protein from the carbohydrates that it consumes. This, together with the fact that the cow can produce its vitamines B and C, should make cow feeding simple and cheap and should not necessitate the feeding of high priced protein foods reinforced with all types of vitamins.

Milk sugar. Lactose is milk sugar and is found only in milk. It is synthesized in the mammary gland and is composed of the two simpler sugars, glucose and galactose. Lactose is split into its simpler components by hydrolysis which is stimulated by the enzyme lactase of the digestive tract or of bacterial origin. Other enzymes split the sugars further to lactic acid which gives the characteristic odor to sour milk. Lactose is not very sweet, i.e., only about 15% as sweet as cane sugar. Lactose is used extensively in infant feeding.

Influence of Breed on Composition. This is important, especially in relation to the fat content.

Table 6. Composition of Milk by Breeds of Purebred Dairy Cows

Breed	Fat %	Protein %	Lactose %	Total Solids %	Solids Not-fat %	Ratio: Fats to Solids Not-fat
Holstein	3.40	3.32	4.87	12.26	8.86	1: 2.61
Shorthorn	3.94	3.32	4.99	12.81	8.87	1: 2.26
Ayrshire	4.00	3.58	4.67	12.90	8.90	1: 2.23
Brown Swiss	4.01	3.61	5.04	13.41	9.40	1: 2.34
Guernsey	4.95	3.91	4.93	14.61	9.66	1: 1.97
Jersey	5.37	3.92	4.93	14.93	9.56	1: 1.78

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Variation in Composition of Cow Milk

Fat	2.60	to	8.37%
Protein	2.44	to	6.48%
Lactose	2.41	to	6.11%
Ash	0.56	to	0.936%
Total Solids	10.56	to	17.90%
Solids-not-fat	7.20	to	11.90%
Specific gravity	1.0231	to	1.0398

Table 7. Comparison of Human and Cows Milk
(In Grams per 100 c.c.)

	Fat	Protein	Lactose	Minerals						
				Phosphates of			Citrates of		Calcium	
				Calcium	Magnesium	Potassium	Potassium	Sodium	Chloride	Total
Human	3.30	1.50	6.50	0.000	0.027	0.069	0.103	0.055	0.059	0.313
Cow*	3.90	3.20	4.90	0.175	0.103	0.230	0.052	0.222	0.119	0.910

*Average Market-Milk

Physical Properties

Specific gravity. This term is the measure of the relative density of a substance as compared to water. It is derived by comparing the weight of a definite volume of water with an equal volume of other material at the same temperature. Fat is the only important constituent in milk that has a specific gravity of less than 1, meaning that a certain volume of fat is lighter than an equal volume of water at the same temperature. Therefore the greater the fat content of milk the less its specific gravity. Normal average milk has a specific gravity of 1.032 at 60°C., and varies between 1.027 and 1.035. Milk is, thus, heavier than water. The specific gravity of milk is measured by the Quevenne lactometer, New York State Board of Health lactometer, or the Westphal balance. One gallon of milk weighs 8.6 pounds as compared to 8.34 of water.

Color. The white opaque color of milk is due to the interference of passage of light through it by the emulsified fat and colloids. The yellow is due to the carotene, and the greenish hue is due to the lactoflavin or riboflavin in the whey. Blue milk may be due to low solid content and to feeding on certain plants. Milk may show blue color due to the presence of the organism,

Pseudomonas cyanogenes. The red color in milk may result from blood due to an injury or infection of the udder, the feeding on plants containing red pigment such as madder root, or the presence of such organisms as Serratea marcescens (B. prodigiosus is old name) and the pink yeast Torula glutines. Redness due to these organisms is not known to be harmful. Yellow milk may be due to the bacteria Pseudomonas synxantha.

Table 8. Influence of Fat in Milk on Specific Gravity

Fat %	Specific Gravity at 68°F. (20° C.)	Wt. in lbs. per gal. of milk at 68° F.
0.025	1.035	8.63
3.0) 5.0)	1.032*	8.60
10.0	1.023	8.53
15.0	1.016	8.47
20.0	1.011	8.43
25.0	1.007	8.39
30.0	1.003	8.36
35.0	0.998	8.31
40.0	0.993	8.28

*Average specific gravity of Milk.
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Freezing Point. The freezing point of a liquid is reduced in proportion to the amount of dissolved material in it. Milk freezes at 31.01° F. (-.55°C.) This is a very constant point. Variation from this point is used as a measure of adulteration with water. The cryoscope is the instrument used to make this test. Fats, most proteins, and colloidal salts do not contribute appreciably to the lowering of the freezing point since they are not in solution. The lactose, some albumen, chlorides, sodium, and potassium are in solution and therefore do contribute to the lowering of the freezing point.

Boiling Point. The boiling point increases as more substances are dissolved in the milk. The boiling point of milk is 212.3°F. (100.17°C.) at sea level.

Refractive Index. Refraction refers to the bending of light rays as they pass from one medium to another. The bending of the rays depends upon the types of molecules through which the light passes and their concentration. The effect of the bending of light rays can be detected by a refractometer. The refractiveness of milk depends upon the amount and kinds of the dissolved materials and the character of the solvent in milk. The index of refraction is sometimes used to detect adulteration, especially water, but this is not as reliable a measure as the freezing point.

Electrical Conductivity. Due to electrolytes in solution in milk, mostly chlorides, milk can conduct an electric current. Mastitis causes an increase in milk chlorides and therefore the measurement of conductivity of milk may indicate mastitis.

Specific Heat. The specific heat of a substance is the ratio between the amount of heat required to raise a given weight of a substance to a given temperature and the amount of heat required to raise the same amount of water to the same temperature. The calorie is the amount of heat required to raise 1 gram of water from 15 to 16°C., or 1°. The B.t.u. (British thermal unit) is the amount of heat required to raise 1 pound of water 1° F. Understanding specific heat is important in calculating the amount of heat or refrigeration required in pasteurization and cooling. Specific heat depends on the chemical nature and physical state of a substance. This is shown in Table 43.

Coefficient of Expansion. Milk expands when heated and contracts when cooled. The coefficient of expansion is the ratio of increase in volume per degree of increase in temperature. It is important to know this factor especially when filling vats, tanks, bottles and so on. Over-filling a pasteurization tank with cool milk, for example, may lead to spillage when the milk expands on

heating. When products are purchased on a volume basis the coefficient of expansion should be taken into consideration.

Table 9. Specific Heats of Milk and Milk Derivatives

Substance	Specific heat at various temperatures			
	0° C. (32° F.)	15°C. (59° F.)	40°C. (104° F.)	60°C. (140° F.)
Whey	0.978	0.976	0.974	0.972
Skim milk	0.940	0.943	0.952	0.963
Whole milk	0.920	0.938	0.930	0.918
15% cream	0.750	0.923	0.899	0.900
30% cream	0.673	0.983	0.852	0.860
45% cream	0.606	1.016	0.787	0.793
Butter	0.512*	0.527*	0.556	0.580
Butter fat	0.445*	0.467*	0.500	0.530

*Values obtained by extrapolation under the assumption that the specific heat is about the same in the solid and liquid states.

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Table 10. Volume of Milk and Cream at Various Temperatures Compared with Unit Volume 1.000 at 68° F.

Fat %	50° F.	60° F.	70° F.	80°F.	90° F.
4	0.9975	0.9985	1.0000	1.0020	1.0040
20	0.9930	0.9975	1.0005	1.0035	1.0070
30	0.9915	0.9965	1.0010	1.0050	1.0095
40	0.9890	0.9950	1.0010	1.0065	1.0115

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Viscosity - This is defined as the resistance to flow, and is due to the friction between molecules. Milk viscosity decreases with the increase in temperature. This property of milk is important because cream is evaluated by the consumer by its viscosity.

Flavors - Fresh, clean milk, unaffected by extraneous factors has a sweetist flavor due mostly to the relation of the lactose and chloride content of the milk. There is an indication that this relation can be expressed mathematically as:

$$\frac{\text{percent chloride}}{\text{percent lactose}} \times 100,$$

and the result has been designated as the chloride-lactose number. It appears that when the chloride-lactose number approaches 2.00, the primary taste of milk becomes unpleasant or reaches the verge of unpleasantness. At least the chances for pleasant taste are much greater below 2.00 than above.

Feed is one of the commonest sources of abnormal flavor in milk. The flavor of feed is found in the milk the shorter the interval between feeding and milking and the greater the amount of feed consumed. That is the reason why it is a practice to feed cows after rather than before milking. A 5-hour interval between feeding and milking will usually prevent tastes from occurring in milk. Practically all kinds of feed produce flavors in milk. A practical method of managing the feeding to reduce the flavors in milk is to feed the cows fully immediately after milking or in the stanchions in the milking stable. In this way the cow will consume only a small amount of feed in the pasture during the interval before the next feeding, thus reducing the possibility of feed flavors. It has been found that when cows are pastured day and night there is less tendency to flavor than when pastured only during the day. If cows be brought in from pasturage before day light, they will have consumed less feed immediately before milking than when they are brought

in at a later hour. If feed flavor in milk is to be entirely controlled, it is necessary to remove the cows from the pasture 5 hours before milking.

Alfalfa and clover are high on the list of feeds that produce flavors; next is alfileria; then green barley, wild oats and rye; and then, cowpeas, corn and foxtail. Full feedings of cabbage or turnips, 1 hour before milking produces definite milk flavors. This is not true for potatoes.

Weeds which produce flavors in milk are tarweed, bitterweed, mustard, wild radish, wild onion, garlic and others. Any feed that is musty or moldy when eaten in appreciable quantities will cause abnormal flavor.

Concentrate feeds such as wheat bran, rolled barley, dried beet pulp, cocoanut meal, soybean meal, cottonseed meal, wet brewers' grains, and mixed concentrate rations may be placed in the mangers to be consumed by the cows previous to milking without causing objectionable flavors.

Milk may absorb odors during handling and storage from some fruits, vegetables, chemicals, paint, coal-tar disinfectants, gasoline, kerosene, fly sprays, fish, other foods and materials. This can be prevented by good ventilation and tight milk containers.

Flavors may result from abnormal conditions in cows. Mastitis may cause off-flavors, especially saltiness. Milk from cows advanced in lactation may produce objectionable flavors especially saltiness. Certain cows have a tendency to produce rancid milk or milk which quickly becomes rancid. The rancidity is caused by the presence of lipase (fat splitting enzyme) in the milk. Cows advanced in lactation that have been milking for a year or more have a tendency to produce such milk. Green feed has a tendency to reduce the incidence of rancid flavors. Some bacteria will cause rancidity. All causes of rancidity in milk are not yet known.

Oxidized or metallic flavors may be caused by containers made of copper and copper alloys such as monel metal, nickle, silver, brass, bronze, waukesha metal and white metal (copper nickle alloys). The flavor is due to the solution of the copper in the milk. Metals that are resistant to solution and do not cause flavors are stainless steel, pure aluminum, pure tin, and glass enameled metals. There is evidence that the oxidation producing the metallic flavor is the result of the action between the dissolved metal and the unsaturated fatty acids of the lecithin or cephalin fractions in the milk. The oxidized flavor will also develop spontaneously in certain milk without the aid of copper. Milk exposed to sunlight will develop an oxidized or tallow-like flavor, probably due to the oxidation of the unsaturated fatty acids in the milk fat, and a change in the proteins.

Sour milk is caused by fermentation. This process is induced by bacteria whose enzymes break down lactose to form lactic acid which in turn curdles the milk protein, casein.

Bitter milk is due to peptones present in the early stage of the decomposition of milk protein by action of such organisms as Strept. liquefaciens and the yeast Torula amara. In the later stage of putrefaction the milk turns putrid and changes into a semi-transparent fluid. Bitter milk may also occur within several hours after milking which may be due to a micrococcus or a bacillus. Herbs such as lupines, wormwood, swedish turnips, cabbage, etc. cause bitterness in milk.

Malty flavors are the result of the growth of Streptococcus lactis (var. maltigenes).

Bitter-moldy taste may be due to Actinomyces organisms.

Potato odor can be caused by Pseudomonas graveolens and Pseudomonas mucidolens.

Microorganisms may cause other unpleasant odors and also pleasant fruity odors.

Slimy or Ropy Milk. This may be caused by abnormal fermentation, occuring mostly in the spring, and due most commonly to Alcaligenes viscosus which usually finds its way into a dairy by way of the water supply. Other bacteria causing this condition are Aerobacter aerogenes, Escherichia neapolitana, Aerobacter cloacae, and Staphlylococcus cremoris viscosi. Ropeness associated with considerable acid may be caused by Streptococcus lactis (var. hollandicus), Lactobacillus casei, and Lactobacillus bulgaricus.

Ropy milk should be distinguished from stringy milk. The latter is due to inflammation of the udder and the strings are composed of masses of fibrin and leucocytes.

Gassy Fermentation. This is due to lactose fermentation by certain non-spore forming yeasts such as Torula cremoris and Torula sphaerica, the Escherichia-Aerobacter group, and certain spore-forming anaerobes of the genus Clostridium.

Sweet Curdling Fermentation. This is the process by which organisms curdle milk or cream through the production of a coagulating enzyme comparable to rennin whereby little or no acid is present. The causative agents are such aerobic spore-forming bacteria as Bacillus albolactis, Bacillus coagulans, and Bacillus calidolactis; non-spore-producing rods of the genus Proteus; various species of cocci such as Streptococcus liquefaciens, and some micrococci; and various yeasts and molds.

Poisons in Milk. Milk sickness in man and trembles in animals results from poisoning with white snake root or the rayless goldenrod when eaten by the cow. The poisons of these plants are secreted in the milk. The disease is primarily one of animals, but transmitted to man through the milk or milk products of the affected cattle.

Solids-not-fat. This refers to all the solids in milk such as protein, lactose, and minerals, which are not fat. Factors which influence the solids-not-fat content of milk are:

1) Variation of fat content is accompanied by a variation of solids-not-fat in the same direction but at a slower rate. An increase of 1.0% fat, for example, is accompanied by an increase of about 0.4% solids-not-fat. The exception to this rule occurs in incomplete milking or "hold-up" of milk in the udder, in which case the fat content decreases resulting in the increase of the proportion of solids-not-fat.

2) Feed affects the solids-not-fat very little if any.

3) Season and Temperature affect solids-not-fat by causing it to decrease in the summer.

4) Infection may cause solids-not-fat to decrease by decreasing the lactose and protein, but the chlorides increase.

The State of Solids in Milk. Fat in milk is in the form of an emulsion; casein and phosphate in colloidal form; lactose and some albumin in molecular form; and chlorides, sodium, and potassium in ionic form.

Chemical Character of Milk.

Milk has an amphoteric (either acid or alkaline) reaction. It turns red litmus blue and blue litmus red. This is due to the mono-and di-phosphates and proteins which may function as either acids or bases at about pH 6.6, the average hydrogen ion concentration of normal milk. When bacteria form lactic acid from lactose and increase the acidity, pasteurization drives off the carbon dioxide and reduces the acidity. The titratable acidity is due mostly to casein and phosphates. The titratable acidity measures the total acidity as distinguished from pH which measures the strength of the acidity or the concentration of hydrogen-ions. The pH is more important in milk than the titratable acidity because the former is so intimately related to the action of enzymes, precipitation of casein, acid taste, and color changes of indicators used in laboratory tests for milk.

Germicidal Property of Milk

There are indications that in very high quality milk, the bacterial count will actually decrease for some hours if left standing at body temperature or less. A report from the University of Illinois showed that high quality milk kept at 50°F. showed no increase in count after 6 hours, and only doubled its bacterial count after 24 hours. The same milk at 60°F. maintained a stationary bacterial count for more than 4 hours, but in 24 hours increased in count by more than 30 times. The same milk kept at 70°F. doubled its count in 6 hours, and increased its count in 24 hours by more than 50 times. Poor quality milk showed no bacteriostatic nor bactericidal character. Heating milk to 75°C. for 15 minutes or 80-90°C. for 2 minutes will destroy the germicidal action of milk. Pasteurization does not affect the germicidal action of milk.

Pasteurization

In the past, the term pasteurization was defined as the process of heating every particle of milk or milk products to at least 143° F., and holding at such temperature for at least 30 minutes, or to at least 160° F., and holding at such temperature for at least 15 seconds, in approved and properly operated equipment (U.S.P.H.S. Milk Code). All bacterial pathogens will be destroyed by heating to 140° F. for 20 minutes, but the pasteurization process allows for an adequate degree of safety. It has, however, recently been found that the incidence of Q fever infection caused by a rickettseal microooorganism is much higher in persons using raw milk from infected cows than those using pasteurized milk. Research has shown that milk pasteurized at 143° F. for 30 minutes still contains some Q fever germs, but that when pasteurized at 145°F. for 30 minutes, or 161° F. for 15 seconds the public health is protected. It is recognized also that milk products, having higher fat content than milk or added sugar should be pasteurized at a temperature of 5° F. higher than milk, i.e., at least 150° F. for 30 minutes, or 166° F. for 15 seconds. The above changes were recommended by the U.S. Public Health Service in July 1956.

Most bacterial toxins will be destroyed at 179°F. Boiling changes taste of milk by denaturing proteins and driving off gases. Pasteurization does not change taste of milk. The pellicle formed on heating milk is caused by the rapid drying of the upper layer. When milk is heated in a closed vessel no pellicle will form.

The various methods of pasteurization are:

1) Holding method —Holding milk at 143°F. for 30 minutes.
2) HTST (high temperature short time) method —Heating milk to 160°F. for 15 seconds electrically or by hot water.
3) Continuous flow method —Heating milk and then running it at a certain rate thru a series of tanks or metal coils.
4) Vat method —Heating milk in a double walled vat or cauldron with coil till it reaches a desired degree and holding it for 30 minutes, after which it is cooled by sending cold water thru double wall or coil.
5) Pasteurization in final container method —Heating the milk in water bath after being bottled.

Difficulties associated with pasteurization are:

1) Maintaining an even temperature in the vat.
2) Keeping thermometers properly functioning.
3) Preventing leakage of valves.
4) Preventing splashing of milk.
5) Maintaining pasteurization temperature in foam or top layer of milk.
6) Preventing growth of thermophilic bacteria and survival of thermodurics.

Advantages of pasteurization are:

1) Decreases epidemics from this source.
2) Increases keeping quality of milk.
3) Does not destroy all the souring organisms.

The time and temperature standard for pasteurization is determined by the time-temperature death point of the tubercle bacilli plus a safety margin.

Adulteration

If the law were to allow low total solids, it would encourage watering of milk. If it were to allow low fat and high total solids content, it would encourage skimming of milk, production from inferior cows, and poor feeding.

The ratio of fat content to total solids may give good information in detection of skimming of milk but the fat-protein ratio is more reliable. The best method for detection of watering of milk is by the process of freezing. Milk freezes at minus .554°C.

The addition of alkalies such as sodium carbonate or sodium bicarbonate is sometimes practiced to neutralize the acidity caused by fermentation, thus improving the taste and delaying curdling.

Condensed skim is sometimes added to increase the total solids in skimmed milk.

Chemical preservatives such as boric acid, salicylic acid, quaternary ammonia, benzoic acid, benzoates, potassium bicarbonate, hydrogen peroxide, fluorides, formaldehyde, etc., are sometimes added to poorly produced milk. It is also possible that antibiotics might be used for this purpose. Such practices are violations of the law.

The laws against adulteration of milk should include the prohibitions against skimming, addition of skimmed or condensed milk, watering, adding alkalies, and adding preservatives. However, if such practices be carried on and the produce be correctly labelled their sale will be within the law unless specific laws be made against the sale of such products.

Denaturing Rejected Milk. When milk is considered unsafe, it may be denatured by adding 0.5 to 1 ounce of rennet and 0.5 to 1 ounce of lampblack to every 10 gallon milk can. Red coal-tar or blueing containing no cyanide may be substituted for lampblack. Such denatured milk may be used for animal feeding.

Milk Standards

Milk standards are usually based on the minimum qualifications necessary to insure good safe milk. Gradually these standards are being raised to higher levels than minimum qualifications. These qualifications are concerned with:

1) Physical properties of milk, i.e., specific gravity, temperature, taste, color, odor, etc.

2) Composition of milk, i.e., percent of butter fat, solids-not-fat, etc.

3) Bacteriological character of milk, i.e., number of microorganisms, absence of pathogens, etc.

4) Sanitary character of the means of production, distribution, and consumption of milk, i.e., mode of dairying, pasteurization, bottling, serving, etc.

Based on the above qualifications, the United States Public Health Service Ordinance and Code have been developed. The 1965 issue of the ordinance is herewith presented:

Grade A Pasteurized Milk Ordinance With Administrative Procedures—1965
Recommendations of the United States Public Health Service

(Each Section and each Item are divided into two parts, (1) the introductory part immediately following the term "Section" or "Item" which is a component of the Ordinance, and (2) the part under the title "Administrative Procedure" which follows the Ordinance portion and is only explanatory methodology.)

An ordinance defining "milk" and certain "milk products," "milk producer," "pasteurization," etc.; prohibiting the sale of adulterated and misbranded milk and milk products; requiring permits for the sale of milk and milk products; regulating the inspection of dairy farms and milk plants, and the examination, labeling, pasteurization, distribution and sale of milk and milk products; providing for the construction of future dairy farms and milk plants, the enforcement of this Ordinance, and the fixing of penalties.

Be it ordained by the _____ of _____[1] as follows:

Section 1. Definitions. The following definitions shall apply in the interpretation and the enforcement of this Ordinance:

A. Milk. Milk is hereby defined to be the lacteal secretion, practically free from colostrum, obtained by the complete milking of one or more healthy cows, which contains not less than 8 1/4 percent milk solids-not-fat and not less than 3 1/4 percent milkfat. (Milkfat or butterfat is the fat of milk.)

A-1. Goat Milk. Goat milk is the lacteal secretion, practically free from colostrum, obtained by the complete milking of healthy goats. The word "milk" shall be interpreted to include goat milk.

B. Cream. Cream is the sweet, fatty liquid separated from milk, with or without the addition of milk or skim milk, which contains not less than 18 percent milkfat.[2]

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1. Substitute proper legal jurisdiction here and in all similar places throughout the Ordinance.
2. Optional ingredients as defined in Section 1, Definition Q, may be used in this product.

B-1. Light Cream, Coffee Cream, or Table Cream. Light cream, coffee cream, or table cream is cream which contains not less than 18 percent but less than 30 percent milkfat.[2]

B-2. Whipping Cream. Whipping cream is cream which contains not less than 30 percent milkfat.[2]

B-3. Light Whipping Cream. Light whipping cream is cream that contains not less than 30 percent but less than 36 percent milkfat.[2]

B-4. Heavy Cream or Heavy Whipping Cream. Heavy cream or heavy whipping cream is cream which contains not less than 36 percent milkfat.[2]

B-5. Whipped Cream. Whipped cream is whipping cream into which air or gas has been incorporated.[2]

B-6. Whipped Light Cream, Coffee Cream, or Table Cream. Whipped light cream, coffee cream, or table cream is light cream, coffee cream, or table cream into which air or gas has been incorporated.[2]

B-7. Sour Cream or Cultured Sour Cream. Sour cream or cultured sour cream is a fluid or semifluid cream resulting from the souring, by lactic acid producing bacteria or similar culture, of pasteurized cream, which contains not less than 0.20 percent acidity expressed as lactic acid.[2]

C. Half-and-Half. Half-and-half is a product consisting of a mixture of milk and cream which contains not less than 10.5 percent milkfat.[2]

C-1. Sour Half-and-Half or Cultured Half-and-Half. Sour half-and-half or cultured half-and-half is fluid or semifluid half-and-half derived from the souring, by lactic acid producing bacteria or similar culture, of pasteurized half-and-half, which contains not less than 0.20 percent acidity expressed as lactic acid.[2]

D. Reconstituted or Recombined Milk and Milk Products. Reconstituted or recombined milk and/or milk products shall mean milk or milk products defined in this section which result from the recombining of milk constituents with potable water.[2,3]

E. Concentrated Milk. Concentrated milk is a fluid product, unsterilized and unsweetened, resulting from the removal of a considerable portion of the water from milk, which, when combined with potable water, results in a product conforming with the standards for milkfat and solids-not-fat of milk as defined above.[2]

E-1. Concentrated Milk Products. Concentrated milk products shall be taken to mean and to include homogenized concentrated milk, vitamin D concentrated milk, concentrated skim milk, fortified concentrated skim milk, concentrated lowfat milk, fortified concentrated lowfat milk, concentrated flavored milk, concentrated flavored milk products, and similar concentrated products made from concentrated milk or concentrated skim milk, and which, when combined with potable water in accordance with instructions printed on the container, conform with the definitions of the corresponding milk products in this section.[2]

F. Skim Milk or Skimmed Milk. Skim milk or skimmed milk is milk from which sufficient milkfat has been removed to reduce its milkfat content to less than 0.50 percent.[2]

G. Lowfat Milk. Lowfat milk is milk from which a sufficient portion of milkfat has been removed to reduce its milkfat content to not less than 0.50 percent and not more than 2.0 percent.[2]

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2. See footnote 2.
3. Where State law does not permit the sale of reconstituted or recombined milk and/or milk products, Definition D and other corresponding references should be omitted.

H. Vitamin D Milk and Milk Products. Vitamin D milk and milk products are milk and milk products, the vitamin D content of which has been increased by an approved method to at least 400 U.S.P. units per quart.[2]

I. Fortified Milk and Milk Products. Fortified milk and milk products are milk and milk products other than vitamin D milk and milk products, the vitamin and/or mineral content of which have been increased by a method and in an amount approved by the health authority.[2]

J. Homogenized milk is milk which has been treated to insure breakup of the fat globules to such an extent that, after 48 hours of quiescent storage at 45° F., no visible cream separation occurs on the milk, and the fat percentage of the top 100 milliliters of milk in a quart, or of proportionate volumes in containers of other sizes, does not differ by more than 10 percent from the fat percentage of the remaining milk as determined after thorough mixing. The word "milk" shall be interpreted to include homogenized milk.[2]

K. Flavored Milk or Milk Products. Flavored milk or milk products shall mean milk and milk products as defined in this Ordinance to which have been added a flavor and/or sweetener.[2]

L. Buttermilk. Buttermilk is a fluid product resulting from the manufacture of butter from milk or cream. It contains not less than 8 1/4 percent of milk solids-not-fat.[2]

L-1. Cultured Buttermilk. Cultured buttermilk is a fluid product resulting from the souring, by lactic acid producing bacteria or similar culture, of pasteurized skim milk or pasteurized lowfat milk.[2]

M. Cultured Milk or Cultured Whole Milk Buttermilk. Cultured milk or cultured whole milk buttermilk is a fluid product resulting from the souring, by lactic acid producing bacteria or similar culture, of pasteurized milk.[2]

N. Acidified Milk and Milk Products. Acidified milk and milk products are milk and milk products obtained by the addition of food grade acids to pasteurized cream, half-and-half, milk, lowfat milk, or skim milk, resulting in a product acidity of not less than 0.20 percent expressed as lactic acid.[2]

O. Milk Products. Milk products include cream, light cream, coffee cream, table cream, whipping cream, light whipping cream, heavy cream, heavy whipping cream, whipped cream, whipped light cream, whipped coffee cream, whipped table cream, sour cream, cultured sour cream, half-and-half, sour half-and-half, cultured half-and-half, reconstituted or recombined milk and milk products, concentrated milk, concentrated milk products, skim milk, skimmed milk, lowfat milk, fortified milk and milk products, vitamin D milk and milk products, homogenized milk, flavored milk or milk products, buttermilk, cultured buttermilk, cultured milk, cultured whole milk buttermilk, and acidified milk and milk products.[2,3,4]

4. Communities desiring to regulate cottage cheese and creamed cottage cheese under the terms of this Ordinance should insert the following definitions:

—— Cottage Cheese: Cottage cheese is the soft uncured cheese obtained by adding lactic-acid-producing bacteria, with or without enzymatic action, to pasteurized skim milk, pasteurized lowfat milk, or pasteurized reconstituted skim milk.[3] It shall contain not more than 80 percent moisture. Cottage cheese may be seasoned with salt.[2]

—— Creamed Cottage Cheese: Creamed cottage cheese is prepared by mixing cottage cheese with a pasteurized creaming mixture consisting of pasteurized cream and milk, dry milk products, concentrated skim milk, skim milk, or lowfat milk, to which salt, lactic acid, and flavor producing bacteria, rennet, lactic acid, citric acid, phosphoric acid or stabilizer may be added. The quantity of milkfat added in the creaming mixture shall be not less than 4 percent by weight of the finished creamed cottage cheese. Dry milk products or concentrated skim milk may be added, provided the amount of added solids does not exceed 3 percent of the weight of the creaming mixture. Creamed cottage cheese shall contain not more than 80 percent moisture.[2]

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2 and 3. See footnotes 2 and 3.

This definition is not intended to include such products as sterilized milk and milk products hermetically sealed in a container and so processed, either before or after sealing, as to prevent microbial spoilage, or evaporated milk, condensed milk, butter, ice cream and other frozen desserts, dry milk products (except as defined herein), or cheese except when they are combined with other substances to produce any pasteurized milk or milk product defined herein.

P. Grade A Dry Milk Products. Grade A dry milk products are milk products which have been produced for use in Grade A pasteurized milk products and which have been manufactured under the provisions of Grade A Dry Milk Products—Recommended Sanitation Ordinance and Code for Dry Milk Products Used in Grade A Pasteurized Milk Products.

Q. Optional Ingredients. Optional ingredients shall mean and include Grade A dry milk products, concentrated milk, concentrated milk products, flavors, sweeteners, stabilizers, emulsifiers, acidifiers, vitamins, minerals, and similar ingredients.

R. Adulterated Milk and Milk Products. Any milk or milk product shall be deemed to be adulterated (1) if it bears or contains any poisonous or deleterious substance in a quantity which may render it injurious to health; (2) if it bears or contains any added poisonous or deleterious substance for which no safe tolerance has been established by State or Federal regulation, or in excess of such tolerance if one has been established; (3) if it consists, in whole or in part, of any substance unfit for human consumption; (4) if it has been produced, processed, prepared, packed, or held under insanitary conditions; (5) if its container be composed, in whole or in part, of any poisonous or deleterious substance which may render the contents injurious to health; or (6) if any substance has been added thereto or mixed or packed therewith so as to increase its bulk or weight, or reduce its quality or strength, or make it appear better or of greater value than it is.

R-1. Misbranded Milk and Milk Products. Milk and milk products are misbranded (1) when their container(s) bear or accompany any false or misleading written, printed or graphic matter; (2) when such milk and milk products do not conform to their definitions as contained in this Ordinance; and (3) when such products are not labeled in accordance with Section 4 of this Ordinance.

S. Pasteurization. The terms "pasteurization," "pasteurized," and similar terms shall mean the process of heating every particle of milk or milk product to at least 145° F., and holding it continuously at or above this temperature for at least 30 minutes, or to at least 161° F., and holding it continuously at or above this temperature for at least 15 seconds, in equipment which is properly operated and approved by the health authority: Provided, That milk products which have a higher milkfat content than milk and/or contain added sweeteners shall be heated to at least 150° F., and held continuously at or above this temperature for at least 30 minutes, or to at least 166° F., and held continuously at or above this temperature for at least 15 seconds, Provided further, That nothing in this definition shall be construed as barring any other pasteurization process which has been recognized by the United States Public Health Service to be equally efficient and which is approved by the State health authority.

T. Sanitization. Sanitization is the application of any effective method or substance to a clean surface for the destruction of pathogens, and of other organisms as far as is practicable. Such treatment shall not adversely affect the equipment, the milk or milk product or the health of consumers, and shall be acceptable to the health authority.

U. Milk Producer. A milk producer is any person who operates a dairy farm and provides, sells, or offers milk for sale to a milk plant, receiving station, or transfer station.

V. Milk Hauler. A milk hauler is any person who transports raw milk and/or raw milk products to or from a milk plant, receiving or transfer station.

W. Milk Distributor. A milk distributor is any person who offers for sale or sells to another any milk or milk products.

X. Health Authority. The health authority shall mean the _____ of the _____[1] or his authorized representative. The term, "Health Authority," wherever it appears in this Ordinance, shall mean the appropriate agency having jurisdiction and control over the matters embraced within this Ordinance.

Y. Dairy Farm. A dairy farm is any place or premises where one or more cows or goats are kept, and from which a part or all of the milk or milk product(s) is provided, sold, or offered for sale to a milk plant, transfer station, or receiving station.

Z. Milk Plant and/or Receiving Station. A milk plant and/or receiving station is any place, premises, or establishment where milk or milk products are collected, handled, processed, stored, pasteurized, bottled, or prepared for distribution.

Z-1. Transfer Station. A transfer station is any place, premises, or establishment where milk or milk products are transferred directly from one transport tank to another.

AA. Official Laboratory. An official laboratory is a biological, chemical, or physical laboratory which is under the direct supervision of the State or a local health authority.

BB. Officially Designated Laboratory. An officially designated laboratory is a commercial laboratory authorized to do official work by the supervising agency, or a milk industry laboratory officially designated by the supervising agency for the examination of producer samples of Grade A raw milk for pasteurization.

CC. Person. The word "person" shall mean any individual, plant operator, partnership, corporation, company, firm, trustee, or association.

DD. And/or. Where the term "and/or" is used, "and" shall apply where appropriate, otherwise "or" shall apply.

Section 2. Adulterated or Misbranded Milk or Milk Products. No person shall, within the municipality of _____ of _____,[1] or its police jurisdiction, produce, provide, sell, offer, or expose for sale, or have in possession with intent to sell any milk or milk product which is adulterated or misbranded: Provided, That in an emergency, the sale of pasteurized milk and milk products which have not been graded, or the grade of which is unknown, may be authorized by the health authority, in which case such products shall be labeled "ungraded".

Any adulterated or misbranded milk or milk product may be impounded by the health authority and disposed of in accordance with applicable laws or regulations.

Administrative Procedures. This section of the Ordinance shall be used in impounding the products of, or preferring charges against, persons who adulterate or misbrand their milk or milk products or label them with any grade designation not authorized by the health authority under the terms of this Ordinance, or who sell or deliver ungraded milk or milk products except as may be permitted under this section in an emergency. An emergency is defined as a general and acute shortage in the milkshed, not simply one distributor's shortage.

Section 3. Permits. It shall be unlawful for any person who does not possess a permit from the health authority of the _____ of _____[1] to bring into, send into, or receive into the _____ of _____[1] or its police jurisdiction, for sale, or to sell, or offer for sale therein, or to have in storage any milk or milk products defined in this Ordinance: Provided, That, grocery stores, restaurants, soda fountains, and similar establishments where milk or milk products are served or sold at retail, but not processed, may be exempt from the requirements of this section.

Only a person who complies with the requirements of this Ordinance shall be entitled to receive and retain such a permit. Permits shall not be transferable with respect to persons and/or locations.

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1. See footnote 1.

The health authority shall suspend such permit, whenever he has reason to believe that a public health hazard exists; or whenever the permit holder has violated any of the requirements of this Ordinance; or whenever the permit holder has interfered with the health authority in the performance of his duties: Provided, That the health authority shall, in all cases, serve upon the holder a written notice of intent to suspend permit, which notice shall specify with particularity the violation(s) in question and afford the holder such reasonable opportunity to correct such violation(s) as may be agreed to by the parties, or in the absence of agreement, fixed by the health authority, before making any order of suspension effective. Provided further, that where the milk or milk product involved creates, or appears to create, an imminent hazard to the public health; or in any case of a willful refusal to permit authorized inspection; or when the bacteria counts, coliform determinations, or cooling temperatures are in violation of the applicable requirements of Section 6 or Section 11, the health authority shall immediately suspend such permit. A suspension of permit shall remain in effect until the violation has been corrected to the satisfaction of the health authority.

Upon written application of any person whose permit has been suspended, or upon application within 48 hours of any person who has been served with a notice of intention to suspend, the health authority shall within 72 hours proceed to a hearing to ascertain the facts of such violation or interference and upon evidence presented at such hearing shall affirm, modify, or rescind the suspension.

Upon repeated violation(s), the health authority may revoke such permit following reasonable notice to the permit holder and an opportunity for a hearing. This section is not intended to preclude the institution of court action as provided in Sections 5 and 6.

Administrative Procedures

Issuance of Permits. Every milk producer, milk distributor, milk hauler, and each milk plant, receiving station, and transfer station operator shall hold a valid permit. Milk producers who transport milk or milk products only from their own dairy farms and employees of a milk distributor or milk plant operator who possesses a valid permit, shall not be required to possess a hauler's permit. Grocery stores, restaurants, soda fountains, and similar establishments where milk or milk products are served or sold at retail but not processed, may be exempt from the requirements of this section.

Suspension of Permit. When any requirement(s) of this Ordinance is violated, the permit holder is subject to the suspension of his permit.

The health authority may forego suspension of the permit, provided the product or products in violation are not sold or offered for sale.

Hearings. If a State or municipal administrative procedure act which provides procedures for administrative hearings and judicial review of administrative determinations is available, the act shall be made applicable by reference to the hearings provided for in the Ordinance. If such administrative procedure act is not available, appropriate procedures, including provision for notice, hearing officer, and his authority, record of hearing, rules or evidence, and court review shall be established by appropriate authority.

Reinstatement of Permits. Any producer, distributor, hauler, or plant operator whose permit has been suspended may make written application for the reinstatement of his permit.

When the permit suspension has been due to a violation of any of the bacterial, coliform, or cooling-temperature standards, the health authority within 1 week after the receipt of a written application for reinstatement of permit, shall issue a temporary permit after determining by an inspection of the facilities and operating methods that the conditions responsible for the violation have been corrected. Samples shall then be taken at the rate of not more than two per week on separate days within a 3-week period, and the health authority shall reinstate the permit upon compliance with the appropriate standard as determined in accordance with Section 6 of this Ordinance.

Whenever the permit suspension has been due to a violation of a requirement other than the

bacteriological, coliform, or cooling-temperature standards, the application shall contain a written statement to the effect that the violation(s) has been corrected. Within 1 week of the receipt of such an application, the health authority shall make an inspection of the applicant's establishment, and as many additional inspections thereafter as are deemed necessary, to determine that the applicant's establishment is complying with the requirements. When the findings justify, the permit shall be reinstated.

Section 4. Labeling. All bottles, containers, and packages enclosing milk or milk products defined in Section 1 of this Ordinance shall be conspicuously labeled or marked with (1) the name of the contents as given in the definition in this Ordinance; (2) the word "reconstituted" or "recombined" if the product be made by reconstitution or recombination;[3] (3) the grade of contents; (4) the word "pasteurized" if the contents be pasteurized and the identity of the plant where pasteurized; (5) the word "raw" if the contents be raw and the name or other identity of the producer; (6) the designation "vitamin D" and the number of U.S.P. units per quart in the case of vitamin D milk or milk products; (7) the volume or proportion of water to be added for recombining in the case of concentrated milk or milk products; (8) the words "nonfat milk solids added" and the percentage added if such solids have been added, except that requirement shall not apply to reconstituted or recombined milk or milk products; (9) the words "artificially sweetened" in the name if non-nutritive and/or artificial sweeteners be used; and (10) the common name of stabilizers, distillates, and ingredients: Provided, That (a) only the identity of the milk producer shall be required on cans delivered to a milk plant which receives only Grade A raw milk for pasteurization, and which immediately dumps, washes, and returns the cans to the milk producer; (b) the identity of both milk producer and the grade shall be required on cans delivered to a milk plant which receives both Grade A raw milk for pasteurization and ungraded raw milk, and which immediately dumps, washes, and returns the cans to the milk producer; (c) in the case of concentrated milk products, the specific name of the product shall be substituted for the generic term "concentrated milk products" e.g., "homogenized concentrated milk," "concentrated skim milk," "concentrated chocolate milk," "concentrated chocolate flavored lowfat milk"; (d) in the case of flavored milk or flavored reconstituted milk, the name of the principal flavor shall be substituted for the word "flavored," * and (e) in the case of cultured milk and milk products, the special type culture used may be substituted for the word "cultured," e.g., "acidophilus buttermilk," "bulgarian buttermilk," and "yogurt".

All vehicles and transport tanks containing milk or milk products shall be legibly marked with the name and address of the milk plant or hauler in possession of the contents.

Tanks transporting raw milk and milk products to a milk plant from sources of supply not under the routine supervision of the health authority are required to be marked with the name and address of the milk plant or hauler and shall be sealed; in addition, for each such shipment, a shipping statement shall be prepared containing at least the following information:

(1) Shipper's name, address, and permit number.
(2) Permit number of hauler, if not employee of shipper.
(3) Point of origin of shipment.
(4) Tanker identity number.
(5) Name of product.
(6) Weight of product.
(7) Grade of product.
(8) Temperature of product.
(9) Date of shipment.
(10) Name of supervising health authority at the point of origin.
(11) Whether the contents are raw, pasteurized, or otherwise heat treated.

* The Federal Food and Drug Administration considers the term "chocolate milk" misleading unless the flavoring ingredient used be "chocolate," "sweet chocolate," or "milk chocolate" complying with the appropriate standards of identity for these products. Milk and milk products flavored with "cocoa" may be labeled "chocolate flavored".

Such statement shall be prepared in triplicate and shall be kept on file by the shipper, the consignee, and the carrier for a period of 6 months for the information of the health authority.

The labeling information which is required on all bottles, containers or packages of milk or milk products shall be in letters of an acceptable size, kind, and color satisfactory to the health authority and shall contain no marks or words which are misleading.

Administrative Procedures

Emergency Supplies—Labeling. When the sale of ungraded milk or milk products is authorized during emergencies, under the terms of Section 2, the label must bear the designation "ungraded". When such labeling is not available, the health authority shall take immediate steps to inform the public that the particular supply is ungraded, and that the supply will be properly labeled as soon as the distributor can obtain the required labels.

Identity Labeling. "Identity," as used in this section, is defined as the name and address of the milk plant at which the pasteurization takes place. It is recommended that the voluntary national uniform coding system for identification of pasteurization plants at which milk and milk products are packaged, be adopted in order to provide a uniform system of codes throughout the country.

In cases where several pasteurization plants are operated by one firm, the common firm name may be utilized on milk bottles or containers: Provided, That the location of the plant at which the contents were pasteurized is also shown, either directly or by a code. This requirement is necessary in order to enable the health authority to identify the source of the pasteurized milk. The street address of the pasteurizing plant need not be shown when only one plant of a given name is located within the municipality.

The identity labeling requirement may be interpreted as permitting plants and persons to purchase and distribute, under their own label, milk and milk products processed and packaged at another plant, provided, that the label reads, "Processed at _____ (name and address)," or that the processing and packaging plant is identified by a proper code.

Misleading Lables. The health authority shall not permit the use of any misleading marks, words, or endorsements upon the label. He may permit the use of registered trade designs or similar terms on the bottle cap or label when, in his opinion, they are not misleading and are not so used as to obscure the labeling required by the Ordinance. The use of super grade designations shall not be permitted. Grade designations such as "Grade AA Pasteurized," "Selected Grade A Pasteurized," "Special Grade A Pasteurized," "Premium," etc., give the consumer the impression that such a grade is significantly safer than Grade A pasteurized. Such an implication is false, because the Ordinance requirements for Grade A pasteurized milk, when properly enforced, will insure that this grade of milk will be as safe as milk can practicably be made.

Section 5. Inspection of Dairy Farms and Milk Plants. Each dairy farm, milk plant, receiving station, and transfer station whose milk or milk products are intended for consumption within _____[1] or its police jurisdiction shall be inspected by the health authority prior to the issuance of a permit. Following the issuance of a permit, each dairy farm and transfer station shall be inspected at least once every 6 months and each milk plant and receiving station shall be inspected at least once every 3 months. Should the violation of any requirement set forth in Section 7 be found to exist, a second inspection shall be required after the time deemed necessary to remedy the violation, but not before 3 days: the reinspection shall be used to determine compliance with the requirements of Section 7. Any violation of the same requirement of Section 7 on such reinspection shall call for permit suspension in accordance with Section 3 and/or court action.

Note. Milk or milk products shall be labeled in accordance with the provisions of Section 4 of this Ordinance and, when shipped interstate, shall fulfill the applicable requirements of the Federal Food, Drug, and Cosmetic Act, as amended.

1. See footnote 1.

One copy of the inspection report shall be handed to the operator, or other responsible person, or be posted in a conspicuous place on an inside wall of the establishment. Said inspection report shall not be defaced and shall be made available to the health authority upon request. An identical copy of the inspection report shall be filed with the records of the health authority.

Every milk producer, hauler, distributor, or plant operator shall, upon request of the health authority, permit access of officially designated persons to all parts of his establishment or facilities to determine compliance with the provisions of this Ordinance. A distributor or plant operator shall furnish the health authority, upon request, for official use only, a true statement of the actual quantities of milk and milk products of each grade purchased and sold, and a list of all sources of such milk and milk products, records of inspections, tests, and pasteurization time and temperature records.

It shall be unlawful for any person who in an official capacity obtains any information under the provisions of this Ordinance which is entitled to protection as a trade secret (including information as to quantity, quality, source or disposition of milk or milk products, or results of inspections or tests thereof) to use such information to his own advantage or to reveal it to any unauthorized person.

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Inspection Frequency. One producer inspection every 6 months or one plant inspection every 3 months is not a desirable frequency; it is instead a legal minimum. Dairy farms and milk plants experiencing difficulty meeting requirements should be visited more frequently. Inspections of dairy farms shall be made at milking time as often as possible, and of milk plants at different times of the day, in order to ascertain if the processes of equipment assembly, sanitizing, pasteurization, cleaning, and other procedures comply with the requirements of this Ordinance.

Enforcement Procedure. This section provides that a dairy farm or milk plant shall be subject to suspension of permit, and/or court action, if two successive inspections disclose violation of the same requirement.

Experience has demonstrated that a strict enforcement of the Ordinance leads to a better and friendlier relationship between the health authority and the milk industry than does a policy of enforcement which seeks to excuse violations and to defer penalty therefor. The sanitarian's criterion of satisfactory compliance should be neither too lenient nor unreasonably stringent. When a violation is discovered, the sanitarian should point out to the milk producer or plant operator the requirement that has been violated, discuss a method for correction, and set a time for correcting the violated requirement.

The penalities of suspension or revocation of permit, and/or court action, are provided to prevent continued violation of the provisions of this Ordinance but are worded to protect the dairy industry against unreasonable or arbitrary action. When a condition is found which constitutes an imminent health hazard, prompt action is necessary to protect the public health; therefore, the health authority is authorized, in Section 3, to suspend the permit immediately. However, except for such emergencies, no penalty is imposed on the producer or distributor upon the first violation of any of the sanitation requirements listed in Section 7. A producer or distributor found violating any requirement must be notified in writing and given a reasonable time to correct the violation(s) before an official reinspection is made. The requirement of giving written notice shall be deemed to have been satisfied by the handing to the operator or by the posting of an inspection report, as required by this section. After receipt of a notice of violation, but before the allotted time has elapsed, the producer or distributor shall have an opportunity to appeal the sanitarian's interpretation to the health authority or for an extension of the time allowed for correction.

Certified Industry Inspection. The health authority may certify industry personnel to carry out cooperatively the provisions of this Ordinance with respect to the supervision of dairy farms. Reports of all inspections conducted by such personnel to determine compliance with

the provisions of this Ordinance shall be forwarded to the health authority. All punitive actions and all inspections for the issuance or reinstatement of permits shall be certified annually by the health authority.

Inspection Reports. A copy of the inspection report shall be filed by the health authority and retained for at least 12 months. The results shall be entered on appropriate ledger forms. The use of a computer or other information retrieval system may be used.

Section 6. The Examination of Milk and Milk Products. During any consecutive 6 months, at least four samples of raw milk for pasteurization shall be taken from each producer and four samples of raw milk for pasteurization shall be taken from each milk plant after receipt of the milk by the milk plant and prior to pasteurization. In addition, during any consecutive 6 months, at least four samples of pasteurized milk and at least four samples of each milk product defined in this Ordinance shall be taken from every milk plant. Samples of milk and milk products shall be taken while in possession of the producer or distributor at any time prior to final delivery. Samples of milk and milk products from dairy retail stores, food service establishments, grocery stores, and other places where milk and milk products are sold shall be examined periodically as determined by the health authority; and the results of such examination shall be used to determine compliance with Sections 2, 4, 10. Proprietors of such establishments shall furnish the health authority, upon his request, with the names of all distributors from whom milk or milk products are obtained.

Required bacterial counts and cooling temperature checks shall be performed on raw milk for pasteurization. In addition, antibiotic tests on each producer's milk or on commingled raw milk shall be conducted at least four times during any consecutive 6 months. When commingled milk is tested, all producers shall be represented in the sample. All individual sources of milk shall be tested when test results on the commingled milk are positive. Required bacterial counts, coliform determinations, phosphatase, and cooling temperature checks shall be performed on pasteurized milk and milk products.

Whenever a phosphatase test is positive, the cause shall be determined. Where the cause is improper pasteurization, it shall be corrected; and any milk or milk product involved shall not be offered for sale.

Samples shall be analyzed at an official or appropriate officially designated laboratory. All sampling procedures and required laboratory examinations shall be in substantial compliance with the _____ Edition of Standard Methods for the Examination of Dairy Products of the American Public Health Association, and the _____ Edition of Official Methods of Analyses of the Association of Official Agricultural Chemists. (Insert edition number current at time of adoption). Such procedures and examinations shall be evaluated in accordance with the methods of evaluating milk laboratories recommended by the United States Public Health Service. Examinations and tests shall be conducted to detect adulterants, including pesticides, as the health authority shall require. Assays of vitamin D milk or milk products and/or fortified milk and milk products shall be made at least annually in a laboratory acceptable to the health authority.

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Enforcement Procedures. Whenever two of the last four consecutive bacterial counts, coliform determinations, or cooling temperatures, taken on separate days, exceed the limit of the standard for the milk and/or milk product, the health authority shall send a written notice thereof to the person concerned. This notice shall be in effect so long as 2 of the last 4 consecutive samples exceed the limit of the standard. An additional sample shall be taken within 14 days of the sending of such notice, but not before the lapse of 3 days. Immediate suspension of permit in accordance with Section 3 and/or court action shall be instituted whenever the standard is violated by three of the last five bacteria counts, coliform determinations, or cooling temperatures.

All violations of bacterial, coliform, and cooling temperatures standards shall be followed promptly by inspection to determine and correct the cause.

Laboratory Techniques. Procedures for the collection and holding of samples; the selection and preparation of apparatus, media and reagents; and the analytical procedures, incubation, reading, and reporting of results, shall be in substantial compliance with Standard Methods for the Examination of Dairy Products and the Official Methods of Analyses. The procedures shall be those specified therein for:

(1) Standard plate count at 32° C.
(2) Simplified methods for viable counts of raw milk at 32° C.
(3) Coliform test with solid media at 32° C.
(4) Disc assay methods for antibiotics.
(5) APHA or AOAC phosphatase tests.

The phosphatase test is an index of the efficiency of the pasteurization process. In the event that the laboratory phosphatase test be positive, the cause shall be determined immediately. Where the cause is improper pasteurization, it shall be corrected. When a laboratory phosphatase test is positive, or if any doubt should arise as to the compliance of the equipment, standards or methods outlined in Section 7, item 16p., the health authority should immediately conduct field phosphatase tests at the plant.

The direct microscopic count is useful as a screening test to detect suspicious tanker loads of milk for subsequent official examinations, and to determine the possible presence of abnormal milk.

Sampling Procedures. When samples of raw milk for pasteurization are taken at a milk plant prior to pasteurization, they shall be drawn following adequate agitation from randomly selected storage tanks.

When bacterial counts are made of several samples of the same milk or milk products collected from the same supply, on the same day, these counts are averaged arithmetically, and the results recorded as the count of the milk or the milk product for that day. All counts should be recorded on the milk-ledger form PHS 1784 (or a similar form) for dairy farms, and form PHS 1782 (or a similar form) for milk plants as soon as reported by the laboratory.

The use of a computer or other information retrieval system may be used.

Section 7. Standards for Milk and Milk Products. All Grade A raw milk for pasteurization and all Grade A pasteurized milk and milk products shall be produced, processed, and pasteurized to conform with the following chemical, bacteriological, and temperature standards, and the sanitation requirements of this section.

No process or manipulation other than pasteurization, processing methods integral therewith, and appropriate refrigeration shall be applied to milk and milk products for the purpose of removing or deactivating microorganisms.

Note. The industry should be encouraged by the health authority to achieve day-to-day compliance with the foregoing standards by performing tests on each producer's milk, including platform tests for odors, temperature, and sediment. Bacterial counts should be conducted following laboratory pasteurization as a check for thermoduric organisms. Examinations for the presence of psychrophilic bacteria are also recommended. Periodic screening tests for presence of added water, antibiotics, and pesticide residues should be performed on producer milk. Plants should reject milk of abnormal odor and high temperature as well as milk that is found to be unsatisfactory by the sediment test. Followup inspections on the dairy farm should be made by the plant fieldman to determine the cause and to institute corrective measures whenever milk is rejected by the milk plant.

Chemical, Bacteriological, and Temperature Standards for Grade A Milk and Milk Products

Grade A raw milk for pasteurization.	Temperature	Cooled to 50° F., or less and maintained thereat until processed.
	Bacterial limits	Individual producer milk not to exceed 100,000 per ml. prior to commingling with other producer milk.
		Not exceeding 300,000 per ml. as commingled prior to pasteurization.
	Antibiotics	No detectable antibiotic residues.
Grade A pasteurized milk and milk products (except cultured products).	Temperature	Cooled to 45° F., or less and maintained thereat.
	Bacterial limits	Milk and milk products—20,000 per ml.
	Coliform limit	Not exceeding 10 per ml.
	Phosphatase	Less than 1 μg per ml. by Scharer Rapid Method (or equivalent by other means).
Grade A. pasteurized cultured products.	Temperature	Same as above.
	Coliform limit	Do.
	Phosphatase	Do.
	Bacterial limits	Exempt.

Sanitation Requirements for Grade A Raw Milk for Pasteurization

Item 1r. Abnormal Milk. Cows which show evidence of the secretion of abnormal milk in one or more quarters, based upon bacteriological, chemical, or physical examination, shall be milked last or with separate equipment; and the milk shall be discarded. Cows treated with, or cows which have consumed chemical, medicinal or radioactive agents which are capable of being secreted in the milk and which, in the judgment of the health authority, may be deleterious to human health, shall be milked last or with separate equipment, and the milk disposed of as the health authority may direct.

Administrative Procedures. This item is deemed to be satisfied when:

1. Milk from cows being treated with medicinal agents, which are capable of being secreted in the milk, is not offered for sale for such period as is recommended by the attending veterinarian or as indicated on the package label of the medicinal agent.

2. Milk from cows treated with or exposed to insecticides not approved for use on dairy cattle by the U.S. Department of Agriculture is not offered for sale.

3. The health authority requires such additional tests for the detection of abnormal milk as he deems necessary.

4. Bloody, stringy, off-colored milk, or milk that is abnormal to sight or odor, is so handled and disposed of as to preclude the infection of other cows and the contamination of milk utensils.

5. Cows secreting abnormal milk are milked last or in separate equipment which effectively prevents the contamination of the wholesome supply.

6. Equipment, utensils, and containers used for the handling of abnormal milk are not used for the handling of milk to be offered for sale, unless they be first cleaned and effectively sanitized.

Item 2r. Milking Barn, Stable, or Parlor—Construction. A milking barn, stable, or parlor shall be provided on all dairy farms in which the milking herd shall be housed during milking

time operations. The areas used for milking purposes shall (1) have floors constructed of concrete or equally impervious material; (2) have walls and ceilings which are smooth, painted or finished in an approved manner, in good repair, ceiling dusttight; (3) have separate stalls or pens for horses, calves, and bulls; (4) be provided with natural and/or artificial light, well distributed for day and/or night milking; (5) provide sufficient air space and air circulation to prevent condensation and excessive odors; (6) not be overcrowded; and (7) have dusttight covered boxes or bins, or separate storage facilities for ground, chopped, or concentrated feed.

Administrative Procedures. This item is deemed to be satisfied when:

1. A milking barn, stable, or parlor is provided on all dairy farms.

2. Gutters, floors, and feed troughs are constructed of good quality concrete or equally impervious material. Floors shall be easily cleaned (brushed surfaces permitted) and shall be graded to drain and maintained in good repair and free of excessive breaks or worn areas that may create pools.

3. Walls and ceilings are finished with wood, tile, smooth-surfaced concrete, cement plaster, brick, or other equivalent materials with light colored surfaces. Walls, partitions, doors, shelves, windows, and ceilings shall be kept in good repair; and surfaces shall be refinished whenever wear or discoloration is evident.

Whenever feed is stored overhead, ceilings shall be constructed to prevent the sifting of chaff and dust into the milking barn, stable or parlor. If a hay opening be provided from loft into the milking portion of the barn, such opening shall be provided with a dusttight door which shall be kept closed during milking operations.

4. Bull pens, maternity and calf stalls, and horse stalls are partitioned from the milking portion of the barn. Such portions of the barn that are not separated by tight partitions shall comply with all requirements of this item.

5. The milking barn is provided with natural and/or artificial light to insure that all surfaces and particularly the working areas will be plainly visible. The equivalent of at least 10 foot-candles of light in all working areas shall be provided.

6. Air circulation is sufficient to minimize odors and to prevent condensation upon walls and ceilings.

7. Overcrowding is not evidenced by the presence of calves, cows, or other barnyard animals in walks or feed alleys. Inadequate ventilation and excessive odors may also be evidence of an overcrowded barn.

8. Dry feed storage rooms and silo approaches are separated from the milking portion of the barn by tight partitions. Direct openings into the milking barn shall have tight-fitting doors which are kept closed. Metal or wooden feed storage containers shall be of tight construction with dusttight covers.

Item 3r. Milking Barn, Stable, or Parlor—Cleanliness. The interior shall be kept clean. Floors, walls, windows, pipelines, and equipment shall be free of filth and/or litter, and shall be clean. Swine and fowl shall be kept out of the milking barn.

Administrative Procedures. This item is deemed to be satisfied when:

1. The interior of the milking barn, stable, or parlor is kept clean.

2. Leftover feed in feed mangers appears fresh and is not wet or soggy.

3. The bedding material, if used, does not contain more manure than has accumulated since the previous milking.

4. Outside surfaces of pipeline systems located in the milking barn, stable, or parlor are reasonably clean.

5. Gutter cleaners are reasonably clean.

6. All pens, calf stalls, and bull pens, if not separated from the milking barn, stable, or parlor, are clean.

7. Swine and fowl are kept out of the milking barn.

Item 4r. Cowyard. The cowyard shall be graded and drained and shall have no standing pools of water or accumulations of organic wastes: Provided, That in loafing or cattle-housing areas, cow droppings and soiled bedding shall be removed, or clean bedding added, at sufficiently frequent intervals to prevent the soiling of the cow's udder and flanks. Waste feed shall not be allowed to accumulate. Manure packs shall be properly drained and shall provide a reasonably firm footing. Swine shall be kept out of the cowyard.

Administrative Procedures. This item is deemed to be satisfied when:

1. The cowyard, which is the enclosed or unenclosed area adjacent to the milking barn, in which the cows may congregate, including cattle-housing areas and feed lots, is graded and drained; depressions and soggy areas are filled; cow lanes are reasonably dry.

2. Approaches to the barn door and the surroundings of stock watering and feeding stations are solid to the footing of the animal.

3. Wastes from the barn or milkhouse are not allowed to pool in the cowyard. Cowyards which are muddy due to recent rains should not be considered as violating this item.

4. Manure, soiled bedding, and waste feed are not stored or permitted to accumulate therein in such a manner as to permit the soiling of cows' udders and flanks. Cattle-housing areas (stables without stanchions, such as loose-housing stables, pen stables, resting barns, holding barns, loafing sheds, wandering sheds, free-stall housing) shall be considered a part of the cowyard. Manure packs shall be solid to the footing of the animal.

5. Cowyards are kept reasonably free of cattle droppings. Cattle droppings shall not be allowed to accumulate in piles that are accessible to the animals.

Item 5r. Milkhouse or Room—Construction and Facilities. A milkhouse or room of sufficient size shall be provided, in which the cooling, handling, and storing of milk and the washing, sanitizing, and storing of milk containers and utensils shall be conducted.

The milkhouse shall be provided with a smooth floor constructed of concrete or equally impervious material graded to drain and maintained in good repair. Liquid waste shall be disposed of in a sanitary manner; all floor drains shall be accessible and shall be trapped if connected to a sanitary sewer system.

The walls and ceilings shall be constructed of smooth material, in good repair, well painted, or finished in an equally suitable manner.

The milkhouse shall have adequate natural and/or artificial light and be well ventilated.

The milkhouse shall be used for no other purpose than milkhouse operations; there shall be no direct opening into any barn, stable, or into a room used for domestic purposes: Provided, That a direct opening between the milkhouse and milking barn, stable, or parlor be permitted when a tight-fitting self-closing solid door(s) hinged to be single or double acting is provided.

Water under pressure shall be piped into the milkhouse.

The milkhouse shall be equipped with a two-compartment wash vat and adequate hot water heating facilities.

When a transportation tank is used for the cooling and storage of milk on the dairy farm, such tank shall be provided with a suitable shelter for the receipt of milk. Such shelter shall

be adjacent to, but not a part of, the milkroom and shall comply with the requirements of the milkroom with respect to construction, light, drainage, insect and rodent control, and general maintenance.

Administrative Procedures. This item is deemed to be satisfied when:

1. A separate milkhouse of sufficient size is provided for the cooling, handling, and storing of milk and the washing, sanitizing, and storing of milk containers and utensils.

2. The floor of all milkhouses are constructed of good quality concrete (float finish permissible), or equally impervious tile, or brick laid closely with impervious material, or metal surfacing with impervious joints, or other material the equivalent of concrete and maintained free of breaks, depressions, and surface peelings.

3. The floor slopes to drain so that there are no pools of standing water. The joints between the floor and the walls shall be watertight.

4. The liquid wastes are disposed of in a sanitary manner; all floor drains are accessible and are trapped if connected to a sanitary sewer.

5. Walls and ceilings are constructed of smooth dressed lumber or similar material, well painted with a light-colored washable paint, and are in good repair. Surfaces and joints shall be tight and smooth. Sheet metal, tile, cement block, brick, concrete, cement plaster, or similar materials of light color may be used; the surfaces and joints shall be smooth.

6. A minimum of 20 foot-candles of light is provided at all working areas from natural and/or artificial light for milkhouse operations.

7. Windows and solid doors are closed during dusty weather.

8. The milkhouse is adequately ventilated to minimize odors and condensation on floors, walls, ceilings, and clean utensils.

9. Vents, if installed, and lighting fixtures are located to preclude the contamination of bulk milk tanks or clean utensil storage areas.

10. The milkhouse is used for no other purpose than milkhouse operations.

11. There is no direct opening into any barn, stable, or room used for domestic purposes; except that an opening between the milkhouse and milking barn, stable, or parlor is permitted when a tight-fitting self-closing solid door(s) hinged to be single or double acting is provided.

12. A vestibule is used; it complies with the applicable milkhouse construction requirements.

13. The transfer of milk from a bulk-holding/cooling tank to a transport tank is through a hose port located in the milkhouse wall. The port shall be fitted with a tight door, which shall be in good repair. It shall be kept closed except when the port is in use.

14. Water under pressure is piped into the milkhouse.

15. Each milkhouse is provided with facilities for heating water in sufficient quantity and to such temperatures for the effective cleaning of all equipment and utensils.

16. The milkhouse is equipped with a wash-and-rinse vat having at least two compartments. Each compartment must be of sufficient size to accommodate the largest utensil or container used. The cleaning-in-place vat for milk pipelines and milk machines may be accepted as one part of the two-compartment vat: Provided, That the cleaning-in-place station rack in or on the vat and the milking machine inflations and appurtenances be completely removed from the vat during the washing, rinsing, and/or sanitizing of other utensils and

equipment.

17. A suitable shelter is provided for a transportation truck used for cooling and storing milk. Such shelter shall be adjacent to, but not a part of, the milkroom and shall comply with the requirements of the milkroom with respect to construction, light, drainage, insect and rodent control, and general maintenance.

Item 6r. Milkhouse or Room—Cleanliness. The floors, walls, ceilings, windows, tables, shelves, cabinets, wash vats, non-product contact surfaces of milk containers, utensils, and equipment, and other milkroom equipment shall be clean. Only articles directly related to milkroom activities shall be permitted in the milkroom. The milkroom shall be free of trash, animals, and fowl.

Administrative Procedures. This item is deemed to be satisfied when:

1. The milkroom structure, equipment, and other milkroom facilities used in its operation or maintenance are clean at all times.

2. Insecticides, rodenticides, antibiotics, medicinals, etc., are not stored in the milkroom.

3. Vestibules, if provided, are kept clean.

4. Animals and fowl are kept out of the milkroom.

Item 7r. Toilet. Every dairy farm shall be provided with one or more toilets, conveniently located and properly constructed, operated, and maintained in a sanitary manner. The waste shall be inaccessible to flies and shall not pollute the soil surface or contaminate any water supply.

Administrative Procedures. This item is deemed to be satisfied when:

1. There is at least one flush toilet connected to a public sewer system or to an individual sewage-disposal system or a chemical toilet, earth pit privy, or other type of privy. Such sewerage systems shall be constructed and operated in accordance with plans and instructions of the State health authority.

2. A toilet or privy is convenient to the milking barn and the milkroom. There shall be no evidence of human defecation or urination about the premises.

3. No privy opens directly into the milkroom.

4. The toilet room, including all fixtures and facilities, is kept clean and free of flies and odors.

5. Where flush toilets are used, doors to toilet rooms are tight and self-closing. All outer openings in toilet rooms shall be screened or otherwise protected against the entrance of flies.

6. Vents of earth pits are screened.

Item 8r. Water Supply. Water for milkhouse and milking operations shall be from a supply properly located, protected, and operated, and shall be easily accessible, adequate, and of a safe, sanitary quality.

Administrative Procedures. This item is deemed to be satisfied when:

1. The water supply for milkhouse and milking operations is approved as safe by the State health authority.

2. No cross-connection exists between a safe water supply and any unsafe or questionable water supply, or any other source of pollution.

3. There are no submerged inlets through which a safe water supply may be contaminated.

4. The well or other source of water is located and constructed in such a manner that neither underground nor surface contamination from any sewerage systems, privy, or other source of pollution can reach such water supply.

5. New individual water supplies and water supply systems which have been repaired or otherwise become contaminated are thoroughly disinfected before being placed in use. The supply shall be made free of the disinfectant by pumping to waste before any sample for bacteriological testing shall be collected.

6. All containers and tanks used in the transportation of water are sealed and protected from possible contamination. These containers and tanks shall be subjected to a thorough cleaning and a bacteriological treatment prior to filling with potable water to be used at the dairy farm. To minimize the possibility of contamination of the water during its transfer from the potable tanks to the elevated or ground-water storage at the dairy farm, a suitable pump, hose, and fittings shall be provided. When the pump hose and fittings are not being used, the outlets shall be capped and stored in a suitable dustproof enclosure so as to prevent their contamination. The storage tank at the dairy farm shall be constructed of impervious material provided with a dust and rainproof cover, and also provided with an approved-type vent and roof hatch. All new reservoirs or reservoirs which have been cleaned shall be disinfected prior to placing them into service.

7. Samples for bacteriological examination are taken upon the initial approval of the physical structure based upon the requirements of this Ordinance and when any repair or alteration of the water supply system has been made: Provided, That when water is hauled to the dairy farm, such water shall be sampled for bacteriological examination at the point of use and submitted to a laboratory each month. Bacteriological examinations shall be conducted in a laboratory acceptable to the health authority.

8. Current records of water test results are retained on file with the health authority or as the health authority directs.

Item 9r. Utensils and Equipment—Construction. All multiuse containers, equipment, and utensils used in the handling, storage, or transportation of milk shall be made of smooth, nonabsorbent, corrosion-resistant, nontoxic materials, and shall be so constructed as to be easily cleaned. All containers, utensils, and equipment shall be in good repair. All milk pails used for hand milking and stripping shall be seamless and of the hooded type. Multiple-use woven material shall not be used for straining milk. All single-service articles shall have been manufactured, packaged, transported, stored, and handled in a sanitary manner and shall comply with the applicable requirements of Item 11p of this section. Articles intended for single-service use shall not be reused.

Farm holding/cooling tanks, welded sanitary piping, and transportation tanks shall comply with the applicable requirements of Items 10p and 11p of this section.

Administrative Procedures. This item is deemed to be satisfied when:

1. The milk-contact surfaces of all multiuse containers, utensils, equipment, piping, and fittings are smooth and constructed of:

a. Stainless steel of the AISI (American Iron and Steel Institute) 300 series, or

b. Equally corrosion-resistant, nontoxic metal; or

c. Heat-resistant glass; or

d. Plastic or rubber and rubberlike materials which are relatively inert, resistant to scratching, scoring, decomposition, crazing, chipping, and distortion, under normal use conditions; are nontoxic, fat resistant, relatively nonabsorbent, relatively insoluble, do not release component chemicals or impart flavor or odor to the product, and which maintain their original properties under repeated-use conditions.

2. Single-service articles have been manufactured, packaged, transported, stored, and

handled in a sanitary manner and comply with the applicable requirements of Item 11p.

3. Articles intended for single service use are not reused.

4. All containers, equipment, and utensils are free of breaks and corrosion.

5. All joints in such containers, equipment, and utensils are smooth and free from pits, cracks, or inclusions.

6. Cleaned-in-place milk pipelines and return-solution lines are self-draining. If gaskets be used, they shall be self-positioning and of material meeting specifications described in (1) (d) above, and shall be of such design, finish, and application as to form a smooth, flush interior surface. If gaskets not be used, all fittings shall have self-positioning faces designed to form a smooth, flush interior surface. All interior surfaces of welded joints in pipelines shall be smooth and free of pits, cracks, and inclusions.

7. Detailed plans for cleaned-in-place pipeline systems are submitted to the health authority for written approval prior to installation. No alteration or addition shall be made to any milk pipeline system without prior written approval of the health authority.

8. Strainers, if used, are of perforated metal design, or so constructed as to utilize single-service strainer media.

9. Seamless hooded pails having an opening not exceeding one-third the area of that of an open pail of the same size are used.

10. All milking machines, including heads, milk claws, milk tubing, and other milk-contact surfaces can be easily cleaned and inspected.

11. Milk cans have umbrella-type lids.

12. Farm holding/cooling tanks, welded sanitary piping, and transportation tanks comply with the applicable requirements of Items 10p and 11p of this section.

Item 10r. Utensils and Equipment—Cleaning. The product-contact surfaces of all multiuse containers, equipment, and utensils used in the handling, storage, or transportation of milk shall be cleaned after each usage.

Administrative Procedures. This item is deemed to be satisfied when:

1. The product-contact surfaces of all multiuse containers, equipment, and utensils used in the handling, storage, or transportation of milk are cleaned after each usage.

Item 11r. Utensils and Equipment—Sanitization. The product-contact surfaces of all multiuse containers, equipment, and utensils used in the handling, storage, or transportation of milk shall be sanitized before each usage.

Administrative Procedures. This item is deemed to be satisfied when:

1. All product-contact surfaces of multiuse containers, utensils, and equipment used in the handling, storage, or transportation of milk are sanitized before each usage by one of the

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Note. 3-A Sanitary Standards. 3-A Sanitary Standards for dairy equipment are promulgated jointly by the Sanitary Standards Subcommittee of the Dairy Industry Committee, the Committee on Sanitary Procedure of the International Association of Milk, Food and Environmental Sanitarians, Inc., and the Milk and Food Branch, Division of Environmental Engineering and Food Protection, Public Health Service, Department of Health, Education, and Welfare. Equipment manufactured in conformity with 3-A Sanitary Standards complies with the sanitary design and construction standards of this Ordinance.

following methods, or by any method which has been demonstrated to be equally effective:

a. Exposure to steam for at least 15 minutes at a temperature of at least 170° F., or for at least 5 minutes at a temperature of at least 200° F., in a steam cabinet equipped with an indicating thermometer which is located in the coldest zone.

b. Exposure to an enclosed jet of steam for not less than 1 minute.

c. Complete immersion in hot water at a temperature of at least 170° F. for at least 5 minutes, or exposure to a flow of hot water at a temperature of at least 170° F. as determined by use of a suitable accurate thermometer (at the outlet) for at least 5 minutes.

d. Exposure to hot air at a temperature of at least 180° F. for at least 20 minutes in a properly designed oven or hot-air cabinet which is equipped with an acceptable indicating thermometer located in the coldest zone.

e. Complete immersion for at least 1 minute in, or exposure for at least 1 minute to a flow of a chemical sanitizer of acceptable strength. All product-contact surfaces must be wetted by the sanitizing solution, and piping so treated must be filled. Sanitizing sprays may be used. Chemical solutions, once used, shall not be reused for sanitizing but may be reused for other purposes.

Item 12r. Utensils and Equipment—Storage. All containers, utensils, and equipment used in the handling, storage, or transportation of milk, unless stored in sanitizing solutions, shall be stored to assure complete drainage, and shall be protected from contamination prior to use.

Administrative Procedures. This item is deemed to be satisfied when:

1. All milk containers, utensils, and equipment, including milking machine vacuum hoses, are stored in the milkhouse in a steam or hotair cabinet, in a sanitizing solution, or on racks, until used. Pipeline milking systems which are cleaned-in-place may be stored in place when such pipelines and appurtenances terminate in the milkhouse or are closed to the atmosphere during storage.

2. Means are provided to effect complete drainage of equipment when such equipment cannot be stored to drain freely.

3. Clean cans or other containers are stored in the milkhouse within a reasonable time after delivery to the dairy farm.

4. Strainer pads, parchment papers, gaskets, and similar single-service articles are stored in a suitable container or cabinet and protected against contamination.

Item 13r. Utensils and Equipment—Handling. After sanitization, all containers, utensils, and equipment shall be handled in such manner as to prevent contamination of any product-contact surface.

Administrative Procedures. This item is deemed to be satisfied when:

1. Sanitized product-contact surfaces, including farm cooling holding tank openings and outlets, are protected against contact with unsanitized equipment and utensils, hands, clothing, splash, condensation, and other sources of contamination.

2. Any sanitized product-contact surface, which has been otherwise exposed to contamination, is again cleaned and sanitized before being used.

Item 14r. Milking—Flanks, Udders, and Teats. Milking shall be done in the milking barn, stable, or parlor. The flanks, udders, bellies, and tails of all milking cows shall be free from visible dirt. All brushing shall be completed prior to milking. The udders and teats of all milking cows shall be cleaned and treated with a sanitizing solution just prior to the time of milking, and shall be relatively dry before milking. Wet hand milking is prohibited.

Administrative Procedures. This item is deemed to be satisfied when:

1. Milking is done in a milking barn, stable, or parlor.

2. Brushing is completed prior to milking.

3. Flanks, bellies, tails, and udders are clipped as often as necessary to facilitate cleaning of these areas and are free from dirt.

4. Udders and teats of all milking cows are cleaned and treated with a sanitizing solution and are relatively dry just prior to milking.

5. Wet hand milking is prohibited.

Item 15r. Milking—Surcingles, Milk Stools, and Antikickers. Surcingles, milk stools, and antikickers shall be kept clean and stored above the floor.

Administrative Procedures. This item is deemed to be satisfied when:

1. Milk stools are not padded and are constructed to be easily cleaned.

2. Milk stools, surcingles, and antikickers are kept clean and are stored above the floor in a clean place, either in the milking barn, stable, parlor, or milkhouse, when not in use.

Item 16r. Milking—Transfer and Protection of Milk. Each pail or container of milk shall be transferred immediately from the milking barn, stable, or parlor to the milkhouse. No milk shall be strained, poured, transferred, or stored unless it be properly protected from contamination.

Administrative Procedures. This item is deemed to be satisfied when:

1. The receiving receptacle is raised above the floor (as on a dolly or cart), or placed at a distance from the cows to protect it against manure and splash when milk is poured and/or strained in the milking barn. Such receptacle shall have a tight-fitting cover which shall be closed except when milk is being poured.

2. Each pail or container of milk is transferred immediately from the milking barn, stable, or parlor to the milkhoue.

3. Pails, cans, and other equipment containing milk are properly covered during transfer and storage.

Item 17r. Personnel—Hand-Washing Facilities. There shall be provided adequate handwashing facilities, including running water, soap or detergent, and individual sanitary towels, in the milkhouse and in or convenient to the milking barn, stable, or parlor.

Administrative Procedures. This item is deemed to be satisfied when:

1. Hand-washing facilities are located in the milkhouse and in or convenient to the milking barn, stable or parlor.

2. Hand-washing facilities include soap or detergent, running water, individual sanitary towels, and a lavatory fixture or separate water tap. Utensil wash and rinse vats shall not be considered as handwashing facilities.

Item 18r. Personnel—Cleanliness. Hands shall be washed clean and dried with an individual sanitary towel immediately before milking, before performing any milkhouse function, and immediately after the interruption of any of these activities. Milkers and milk haulers shall wear clean outer garments while milking or handling milk, milk containers, utensils, or equipment.

Administrative Procedures. This item is deemed to be satisfied when:

1. Hands are washed clean and dried with an individual sanitary towel immediately before milking, before performing any milkhouse function, and immediately after the interruption of any of these activities.

2. Milkers and milk haulers wear clean outer garments while milking or handling milk, milk containers, utensils, or equipment.

Item 19r. Cooling. Raw milk for pasteurization shall be cooled to 50° F. or less within 2 hours after milking and shall be maintained at that temperature until delivered.

Administrative Procedures. This item is deemed to be satisfied when:

1. Raw milk for pasteurization is cooled to 50° F. or less within 2 hours after milking and maintained at that temperature until delivered.

Item 20r. Vehicles. Vehicles used to transport milk in cans from the dairy farm to the milk plant or receiving station shall be constructed and operated to protect their contents from sun, freezing, and contamination. Such vehicles shall be kept clean, inside and out; and no substance capable of contaminating milk shall be transported with milk.

Administrative Procedures. This item is deemed to be satisfied when:

1. Vehicles used to transport milk in cans from the dairy farm to the milk plant or receiving station are constructed and operated to protect their contents from sun, freezing, and contamination.

2. Vehicles have bodies with solid enclosures and tight, solid doors.

3. Vehicles are kept clean, inside and out.

4. No substance capable of contaminating the milk is transported with the milk.

See items 9r and 10r for information on the construction of transportation tanks.

Item 21r. Insect and Rodent Control. Effective measures shall be taken to prevent the contamination of milk, containers, equipment, and utensils by insects and rodents, and by chemicals used to control such vermin. Milkrooms shall be free of insects and rodents. Surroundings shall be kept neat, clean, and free of conditions which might harbor or be conducive to the breeding of insects and rodents.

Administrative Procedures. This item is deemed to be satisfied when:

1. Surroundings are kept neat, clean, and free of conditions which might harbor or be conducive to the breeding of insects and rodents. During fly season, manure shall be spread directly on the fields; or stored for not more than 4 days in a pile on the ground surface, and then spread on the fields; or stored for not more than 7 days in an impervious-floored bin, or on an impervious-curbed platform and then spread; or stored in a tight-screened and trapped manure shed; or effectively treated with larvicides; or disposed of in any other manner which controls insect breeding.

2. Manure packs in loafing areas, stables without stanchions, pen stables, resting barns, wandering sheds, and free-stall housing are properly bedded and managed to prevent fly breeding.

3. Milkrooms are free of insects and rodents.

4. Milkrooms are effectively screened or otherwise protected against the entrance of vermin.

5. Outer milkhouse doors are tight and self-closing. Screen doors shall open outward.

6. Effective measures are taken to prevent the contamination of milk, containers, utensils, and equipment by insects and rodents, and by chemicals used to control such vermin.

7. Only pesticides approved for use by the health authority and/or registered with the U.S. Department of Agriculture are used for insect and rodent control.

8. Pesticides are used only in accordance with manufacturer's directions and are used so as to prevent the contamination of milk, milk containers, equipment, utensils, feed, and water.

A receiving station shall comply with Items 1p to 15p, inclusive, and 17p, 20p, and 22p, except that the partitioning requirement of Item 5p shall not apply.

A transfer station shall comply with Items 1p, 4p, 6p, 7p, 8p, 9p, 10p, 11p, 12p, 14p, 15p, 20p, and 22p; and as climatic and operating conditions require, the applicable provisions of Items 2p and 3p: Provided, That in every case, overhead protection shall be provided. Facilities for the cleaning and sanitizing of bulk transport tanks shall comply with Items 1p, 4p, 6p, 7p, 8p, 9p, 10p, 11p, 12p, 14p, 15p, 20p, and 22p; and as climatic and operating conditions require, the applicable provisions of Items 2p and 3p: Provided, That in every case, overhead protection shall be provided.

Item 1p. Floors—Construction. The floors of all rooms in which milk or milk products are processed, handled, or stored, or in which milk containers, equipment, and utensils are washed, shall be constructed of concrete or other equally impervious and easily cleaned material; and shall be smooth, properly sloped, provided with trapped drains, and kept in good repair: Provided, That cold-storage rooms used for storing milk and milk products need not be provided with floor drains when the floors are sloped to drain to one or more exits: Provided further, That storage rooms for storing dry ingredients and/or packaging materials need not be provided with drains: and the floors may be constructed of tightly joined wood.

Administrative Procedures. This item is deemed to be satisfied when:

1. The floors of all rooms in which milk is handled, processed, or stored, or in which milk containers or utensils are washed, are constructed of good quality concrete, or equally impervious tile or brick laid closely with impervious joint material, or metal surfacing with impervious joints, or other material which is the equivalent of good quality concrete. The floors of storage rooms for dry ingredients and/or packaging material may be constructed of tightly joined wood.

2. The floor surface is smooth and sloped, so that there are no pools of standing water after flushing; and the joints between the floor and the walls are impervious.

3. The floors are provided with trapped drains. Cold-storage rooms used for storing milk and milk products need not be provided with floor drains when the floors are sloped to drain to one or more exits. Storage rooms for dry ingredients and/or packaging materials need not be provided with drains.

Item 2p. Walls and Ceilings—Construction. Walls and ceilings of rooms in which milk or milk products are handled, processed, or stored, or in which milk containers, utensils, and equipment are washed, shall have a smooth, washable, light-colored surface, in good repair.

Administrative Procedures. This item is deemed to be satisfied when:

1. Walls and ceilings are finished with smooth, washable, light-colored painted wood, tile, smooth-surface concrete, cement plaster, brick, or other equivalent materials with washable, light-colored surfaces.

2. Walls, partitions, windows, and ceilings are kept in good repair and refinished as often as the finish wears off or becomes discolored.

Item 3p. Doors and Windows. Effective means shall be provided to prevent the access of flies and rodents. All openings to the outside shall have solid doors or glazed windows which shall be closed during dusty weather.

Administrative Procedures. This item is deemed to be satisfied when:

1. All openings to the outer air are effectively screened by (a) screening; or (b) effective electric screen panels; or (c) fans or air curtains which provide sufficient air velocity so as to prevent the entrance of flies; or (d) properly constructed flaps where it is impractical to use self-closing doors or air curtains; or (e) any effective combination of (a), (b), (c), or (d), or

by any other method which prevents the entrance of flies.

2. All outer doors are tight and self-closing. Screen doors shall open outward.

3. All outer openings are rat proofed to the extent necessary to prevent the entry of rodents.

Item 4p. Lighting and Ventilation. All rooms in which milk and milk products are handled, processed, or stored and/or in which milk containers, equipment, and utensils are washed shall be well lighted and well ventilated.

Administrative Procedures. This item is deemed to be satisfied when:

1. Adequate light sources are provided (natural, artificial, or a combination of both) which furnish at least 20 foot-candles of light in all working areas. This shall apply to all rooms where milk or milk products are handled, processed, or stored, or where utensils, containers, and/or equipment are washed. Dry storage and cold storage rooms shall be provided with at least 5 foot-candles of light.

2. Ventilation in all rooms is sufficient to keep them reasonably free of odors and excessive condensation on equipment, walls, and ceilings.

3. Pressurized ventilating systems, if used, have a filtered air intake.

Item 5p. Separate Rooms. There shall be separate rooms for (1) pasteurizing, processing, cooling, and packaging; and (2) cleaning of milk cans and bottles. In addition, plants receiving milk in bulk transport tanks shall provide for cleaning and sanitizing facilities.

Unless all milk and milk products be received in bulk transport tanks, a receiving room, separate from rooms (1) and (2) above, shall be required. Rooms in which milk or milk products are handled, processed, or stored, or in which milk containers, utensils, and equipment are washed or stored, shall not open directly into any stable or any room used for domestic purposes.

Administrative Procedures.* This item is deemed to be satisfied when:

1. Pasteurizing, processing, cooling and packaging are conducted in a single room(s), but not in the same room(s) used for the cleaning of milk cans and bottles. All rooms shall be of sufficient size for their intended purposes.

2. All bulk milk storage tanks are vented into a room used for pasteurization, processing, cooling, or packaging operations, or into a storage tank galley room, provided that vents located elsewhere which are adequately equipped with air filters so as to preclude the contamination of the milk, shall be considered satisfactory.

3. Doors installed in required partitions are self-closing.

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* Communities desiring to regulate cottage cheese and creamed cottage cheese under the terms of this Ordinance should include the following in the administrative procedures of Item 5p.: Cottage cheese vats shall be located in a separate room, maintained free from flies and other vermin, and kept in a clean condition: Provided, That in existing installations, cottage cheese vats may be located in the processing room when there is no evidence of overcrowding, excessive traffic, condensation, or splash. Cottage cheese vats located in processing rooms shall be equipped with multi-service or single-service covers which shall be kept in place at all times during the "setting" operation.

Note. The evidence of insects and/or rodents in the plant shall be considered under Item 9p.

4. Facilities for the cleaning and sanitizing of bulk transport tanks are properly equipped for manual and/or mechanical operations. When such facilities are not provided on the plant premises, these operations shall be performed at a receiving station, transfer station, or separate tank washing installation. (Items relating to facilities for cleaning and sanitizing bulk transport tanks are listed just prior to Item 1p.

5. Rooms in which milk or milk products are handled, processed, or stored, or in which milk containers, utensils, and equipment are washed or stored, do not open directly into any stable or any room used for domestic purposes.

Item 6p. Toilet-Sewage Disposal Facilities. Every milk plant shall be provided with toilet facilities conforming with the ordinances of the _____ of _____.[1] Toilet rooms shall not open directly into any room in which milk and/or milk products are processed. Toilet rooms shall be completely enclosed and shall have tight-fitting, self-closing doors. Dressing rooms, toilet rooms, and fixtures shall be kept in a clean condition, in good repair, and shall be well ventilated and well lighted. Sewage and other liquid wastes shall be disposed of in a sanitary manner.

Administrative Procedures. This item is deemed to be satisfied when:

1. The milk plant is provided with toilet facilities conforming with the ordinances of the _____ of _____.[1]

2. Toilet rooms do not open directly into any room in which milk and/or milk products are processed.

3. Toilet rooms are completely enclosed and have tight-fitting self-closing doors.

4. Dressing rooms, toilet rooms, and fixtures are kept in a clean condition, in good repair, and are well ventilated and well lighted.

5. Toilet tissue and easily cleanable covered waste receptacles are provided in toilet rooms.

6. All plumbing is installed to meet the applicable provisions of the State or local plumbing code.

7. Sewage and other liquid wastes are disposed of in a sanitary manner.

8. Non-water-carried sewage disposal facilities are not used, except where the health authority determines that the use of water-carried-sewage facilities is impractical.

9. When a chemical toilet, earth pit privy, other type privy, or sewage-disposal facilities is provided, each shall be constructed and operated in accordance with plans and instructions of the health authority.

Item 7p. Water Supply. Water for milk plant purposes shall be from a supply properly located, protected, and operated and shall be easily accessible, adequate, and of a safe, sanitary quality.

Administrative Procedures.* This item is deemed to be satisfied when:

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1. See footnote 1.

* Communities desiring to regulate cottage cheese and creamed cottage cheese under the terms of this Ordinance should include the following in the administrative procedures of Item 7p.: "Water supply outlets are provided immediately available to the cottage cheese vats. The hose for transport of water for washing cottage cheese curd shall be arranged in such a way as to preclude the possibility of the hose touching the floor or the product."

1. Water for milk plant purposes is from an adequate supply, properly located, protected, and operated. It shall be easily accessible and of a safe, sanitary quality.

2. The water supply is approved as safe by the State health authority.

3. There is no cross-connection between the safe water supply and any unsafe or questionable water supply, or any source of pollution through which the safe water supply might become contaminated. A connection between the water supply piping and a make-up tank (such as for cooling or condensing), unless protected by an air gap or effective backflow preventor, constitutes a violation of this requirement.

4. Condensing water for milk evaporators, and water used to produce vacuum and/or to condense vapors in vacuum heat processing equipment, is from a source complying with 2 above: Provided, That when approved by the health authority, water from sources not complying with 2 above may be used when the evaporator or vacuum heat equipment is constructed and operated to preclude contamination of such equipment or its contents by condensing water or by water used to produce vacuum.

5. New individual water supplies and water supply systems, which have been repaired or otherwise become contaminated, are disinfected before being placed in use. The supply shall be made free of the disinfectant by pumping to waste before any sample for bacteriological testing shall be collected.

6. Samples for bacteriological testing of individual water supplies are taken upon the initial approval of the physical structure, semiannually thereafter, and when any repair or alteration of the water supply system has been made. Bacteriological examinations shall be conducted in a laboratory acceptable to the health authority.

7. Current records of water test results are retained on file with the health authority or as the health authority directs.

Item 8p. Hand-Washing Facilities. Convenient hand-washing facilities shall be provided, including hot and cold and/or warm running water, soap, and individual sanitary towels or other approved hand-drying devices. Hand-washing facilities shall be kept in a clean condition and in good repair.

Administrative Procedures. This item is deemed to be satisfied when:

1. Convenient hand-washing facilities are provided, including hot and cold and/or warm running water, soap, and individual sanitary towels or other approved hand-drying devices.

2. Hand-washing facilities are convenient to all toilets and to all rooms in which milk plant operations are conducted.

3. Hand-washing facilities are kept in a clean condition and in good repair.

4. Steam-water mixing valves and vats used for washing bottles, cans, and similar equipment are not used as hand-washing facilities.

Item 9p. Milk Plant Cleanliness. All rooms in which milk and milk products are handled, processed, or stored, and/or in which containers, utensils, or equipment are washed or stored, shall be kept clean, neat, and free of evidence of insects and rodents. Pesticides shall be safely used. Only equipment directly related to processing operations or to handling of containers, utensils, and equipment shall be permitted in the pasteurizing, processing, cooling, packaging, and bulk milk storage rooms.

Administrative Procedures. This item is deemed to be satisfied when:

1. Only equipment directly related to processing operations or the handling of containers, utensils, and equipment is permitted in the pasteurizing, processing, cooling, packaging, and bulk milk storage rooms.

2. All piping, floors, walls, ceilings, fans, shelves, tables, and the nonproduct-contact surfaces of other facilities and equipment are clean.

3. No trash or solid waste is stored within the plant, except in covered containers. Waste containers at the packaging machine or bottle washer may be uncovered during operation of such equipment.

4. All rooms in which milk and milk products are handled, processed, or stored, and/or in which containers, utensils, or equipment are washed or stored, are kept clean, neat, and free of evidence of insects and rodents.

5. Pesticides are used safely.

6. Only pesticides approved by the health authority and/or registered with the U.S. Department of Agriculture shall be used for insect and rodent control. Such pesticides shall be used only in accordance with the manufacturers' directions and shall be prevented from contaminating milk, containers, equipment, and utensils.

Item 10p. Sanitary Piping. All sanitary piping, fittings, and connections which are exposed to milk and milk products, or from which liquids may drip, drain, or be drawn into milk or milk products, shall consist of smooth, impervious, corrosion-resistant, nontoxic, easily cleanable material. All piping shall be in good repair. Pasteurized milk and milk products shall be conducted from one piece of equipment to another only through sanitary piping.*

Administrative Procedures. This item is deemed to be satisfied when:

1. All sanitary piping, fittings, and connections which are exposed to milk and milk products, or from which liquids may drip, drain, or be drawn into milk products, consist of smooth, impervious, corrosion-resistant, nontoxic, easily cleanable material.

2. All sanitary piping, connections, and fittings consist of:
   a. Stainless steel of the AISI (American Iron and Steel Institute) 300 series, or
   b. Equally corrosion-resistant metal which is nontoxic and nonabsorbent, or
   c. Heat resistant glass, or
   d. Plastic, or rubber and rubberlike materials which are relatively inert, resistant to scratching, scoring, decomposition, crazing, chipping, and distortion under normal use conditions; which are nontoxic, fat resistant, relatively nonabsorbent; which do not impart flavor or odor to the products; and which maintain their original properties under repeated use conditions.

3. Sanitary piping, fittings, and connections are designed to permit easy cleaning, kept in good repair, and free of breaks or corrosion.

4. All interior surfaces of demountable piping, including valves, fittings, and connections are designed, constructed, and installed to permit inspection and drainage.

5. All cleaned-in-place milk pipelines and return-solution lines are rigid, self-draining, and so supported to maintain uniform slope and alinement. Return solution lines shall be constructed of material meeting the specifications of 2 above. If gaskets be used, they shall be self-positioning, of material meeting the specifications outlined in 2d above, and designed, finished, and applied to form a smooth, flush interior surface. If gaskets not be used, all fittings shall have self-positioning faces designed to form a smooth, flush interior surface. All interior surfaces of welded joints in pipelines shall be smooth and free from pits, cracks, or inclusions.

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* Communities desiring to regulate cottage cheese and creamed cottage cheese under the terms of this Ordinance should add the following: "Provided, That cottage cheese, cheese dressings, or cheese ingredients may be transported by other methods which protect the product from contamination."

In the case of welded lines, all welds shall be inspected by the use of a borescope or other appropriate available inspection device as they are made; and such welds shall be approved by the health authority.

Each cleaning circuit shall have access points for inspection in addition to the entrances and exits. These may be valves, removable sections, fittings, or other means or combinations that are adequate for inspection of the interior of the line. These access points shall be located at sufficient intervals to determine the general condition of the interior surfaces of the line.

Detailed plans for welded pipeline systems shall be submitted to the health authority for written approval prior to installation. No alteration or addition shall be made to any welded milk pipeline system without prior written approval from the health authority.

6. Pasteurized milk and milk products are conducted from one piece of equipment to another only through sanitary milk piping. The health authority may waive this piping requirement for specific milk products when small quantities are handled as to make the requirement impractical, and when such handling is performed so as to preclude product contamination.

Item 11p. Construction and Repair of Containers and Equipment. All multiuse containers and equipment with which milk or milk products come into contact shall be of smooth, impervious, corrosion-resistant, nontoxic material; shall be constructed for ease of cleaning; and shall be kept in good repair. All single-service containers, closures, gaskets, and other articles with which milk or milk products come in contact shall be nontoxic, and shall have been manufactured, packaged, transported, and handled in a sanitary manner. Articles intended for single-service use shall not be reused.

Administrative Procedures. This item is deemed to be satisfied when:

1. All multiuse containers and equipment with which milk or milk products come into contact are of smooth, impervious, corrosion-resistant, and nontoxic material.

2. All milk-contact surfaces of multiuse containers and equipment consist of:
   a. Stainless steel of the AISI (American Iron and Steel Institute) 300 series, or
   b. Equally corrosion-resistant metal which is nontoxic and nonabsorbent, or
   c. Heat resistant glass, or
   d. Plastic or rubber and rubberlike materials which are relatively inert, resistant to scratching, scoring, decomposition, crazing, chipping, and distortion under normal use conditions; which are nontoxic, fat resistant, relatively nonabsorbent, and do not impart flavor or odor to the product; and which maintain their original properties under repeated use conditions.

3. All joints in containers, equipment, and utensils are flush and finished as smooth as adjoining surfaces. Where a rotating shaft is inserted through a surface with which milk or milk products come into contact, the joint between the moving and stationary surfaces shall be close-fitting. Where a thermometer or temperature sensing element is inserted through a surface with which milk or milk products come into contact, a pressure-tight seal shall be provided ahead of all threads and crevices.

4. All openings in covers of tanks, vats, separators, etc., are protected by raised edges, or otherwise to prevent the entrance of surface drainage. Condensation-diverting aprons shall be provided as close to the tank or vat as possible on all pipes, thermometers, or temperature sensing elements, and other equipment extending into a tank, bowl, vat, or distributor, unless a watertight joint be provided.

5. All surfaces with which milk or milk products come into contact are easily accessible or demountable for manual cleaning or are designed for mechanical cleaning. All product-contact surfaces shall be readily accessible for inspection and shall be self-draining. Wing nuts, bayonet locks, and similar devices shall be used whenever possible in lieu of bolts and nuts, to promote easy disassembly.

6. There are no threads used in contact with milk or milk products except where needed for functional and safety reasons, such as in clarifiers, pumps, and separators. Such threads

shall be of a sanitary type.

7. All multiuse containers and other equipment have rounded corners, are in good repair and free from breaks, crevices, and corrosion. Milk cans shall have umbrella-type covers.

8. Strainers, if used, are of perforated metal design, and so constructed as to utilize single-service strainer media. Multiple-use woven material shall not be used for straining milk.

9. All single-service containers, closures, gaskets, and other articles, with which milk or milk products come in contact, are nontoxic.

10. The manufacture, packing, transportation, and handling of single-service containers, closures, caps, gaskets, and similar articles comply with the requirements of Sanitation Guidelines for the Manufacture of Single-Service Containers for Milk and Milk Products, prepared by the Division of Environmental Engineering and Food Protection of the U.S. Public Health Service. Inspections and tests shall be made by the health authority or by any agency authorized by him.

Item 12p. Cleaning and Sanitizing of Containers and Equipment. The product-contact surfaces of all multiuse containers, utensils, and equipment used in the transportation, processing, handling, and storage of milk and milk products shall be effectively cleaned and shall be sanitized before each use.

Administrative Procedures. This item is deemed to be satisfied when:

1. All multiuse containers and utensils are thoroughly cleaned after each use, and all equipment is thoroughly cleaned at least once each day used: Provided, That storage tanks shall be cleaned when emptied and shall be emptied at least every 72 hours.

2. Pipelines and/or equipment designed for mechanical cleaning meet the following requirements:

a. An effective cleaning and sanitizing regimen for each separate cleaning circuit shall be followed.

b. During processing, pipelines and equipment used to contain or conduct milk and milk products shall be effectively separated from tanks or circuits containing cleaning and/or sanitizing solutions.

c. A temperature recording device shall be installed in the return solution line to record the temperature and time during which the line or equipment is exposed to cleaning and sanitizing.

d. Temperature recording charts shall be identified, dated, and retained for 3 months.

e. During each official inspection, the health authority shall examine and initial temperature recording charts to verify the time of exposure to solutions and their temperatures.

3. Plants in which containers are washed manually are equipped with a two-compartment wash-and-rinse vat for this purpose. Such plants shall also provide a steam cabinet or individual steam-jet plate with hood for sanitizing of cleaned containers, or, if sanitizing be done with chemicals, a third treatment vat.

4. All multiuse containers, equipment, and utensils are sanitized before use, employing one or a combination of the methods prescribed under Item 11r. Assembled equipment must be sanitized immediately prior to each day's run. At least once each 3 months, the health authority shall determine the efficiency of sanitization.

5. The residual bacteria count of multiuse and single-service containers used for packaging pasteurized milk and milk products shall not exceed one per ml. of capacity or not over

50 colonies per 8 square inches (one per square centimeter) of product-contact surface in 3-out-of-4 samples taken at random on a given day. All multiuse and single-service containers shall be free of coliform organisms.

Item 13p. Storage of Cleaned Containers and Equipment. After cleaning, all multiuse milk or milk product containers, utensils, and equipment shall be transported and stored to assure complete drainage, and shall be protected from contamination before use.

Administrative Procedures. This item is deemed to be satisfied when:

1. All multiuse containers, equipment, and utensils, after cleaning, are transported and/or stored on metal racks or in clean cases elevated above the floor. Containers shall be stored inverted on racks or in cases constructed of relatively nonabsorbent, corrosion-resistant, nontoxic materials, or otherwise protected from contamination.

2. Floors are not flushed or washed when crates of clean bottles are stacked on them.

Item 14p. Storage of Single-Service Containers, Utensils and Materials. Single-service caps, cap stock, parchment paper, containers, gaskets, and other single-service articles for use in contact with milk and milk products shall be purchased and stored in sanitary tubes, wrappings, or cartons; shall be kept therein in a clean, dry place until used; and shall be handled in a sanitary manner.

Administrative Procedures. This item is deemed to be satisfied when:

1. Single-service caps, cap stock, parchment paper, containers, gaskets, and other single-service articles for use in contact with milk and milk products are purchased and stored in sanitary tubes, wrappings, or cartons; are kept in a clean, dry place until used; and are handled in a sanitary manner.

2. Paperboard containers used to enclose plastic bags are used only once.

3. Tubes or cartons are not refilled with spilled caps, gaskets, or parchment papers.

4. Cartons or boxes from which contents have been partially removed are kept closed.

5. Suitable cabinets are provided for storage of tubes after removal from the large outer box, and for storage of opened cartons, unless other satisfactory means are approved by the health authority.

Item 15p. Protection from Contamination. Milk plant operations, equipment, and facilities shall be located and conducted to prevent any contamination of milk or milk products, ingredients, equipment, containers, and utensils. All milk or milk products or ingredients which have been spilled, overflowed, or leaked shall be discarded. The processing or handling of products other than milk and milk products in the pasteurization plant shall be performed to preclude the contamination of such milk and milk products.

Administrative Procedures. This item is deemed to be satisfied when:

1. Equipment and operations are so located within the plant as to prevent overcrowding and contamination of cleaned and sanitized containers, equipment, and utensils by splash, condensation, or manual contact.

2. All milk and milk products which have overflowed, leaked, been spilled, or improperly handled are discarded. Milk and milk products drained from processing equipment at the end of a run, or collected from a defoamer system which does not continuously return such product to the filler bowl, shall be repasteurized only if such milk or milk products be handled in a sanitary manner and maintained at 45° F. or less. When the handling and/or refrigeration of such milk and milk products are not in compliance with this requirement, they shall be discarded. Returned packaged milk and milk products shall not be repasteurized for Grade A use.

3. All product contact surfaces of containers, equipment, and utensils are covered or

otherwise protected to prevent the access of insects, dust, condensation, and other contamination. All openings, including valves and piping attached to milk storage and transport tanks, pumps, or vats, etc., shall be capped or otherwise properly protected. The application of suitable filters to the manholes of transport tanks during unloading shall be considered satisfactory.

Receiving and dump vats shall be completely covered, except during washing and sanitizing, and when milk is being dumped. Where strainers are used, the cover for the vat opening shall be designed to cover the opening with the strainer in place.

4. Whenever air under pressure is used for the agitation or movement of milk, or is directed at a milk-contact surface, it is free of oil, dust, rust, excessive moisture, extraneous materials, and odor, and shall otherwise comply with the applicable standards. The use of steam containing toxic substances is expressly prohibited. Whenever steam is used in contact with milk or milk products, it shall be of culinary quality and shall comply with the applicable standards.

5. Standardization is done before the pasteurization process is started, unless pasteurized milk or milk products be used for standardization. Such pasteurized milk products shall be protected against contamination. In no case shall pasteurized milk or milk products be standardized with unpasteurized milk unless the standardized product be subsequently pasteurized. Standardization of Grade A milk and milk products with milk and milk products of other than Grade A quality is prohibited. This Ordinance permits standardization as a process of adjusting the butterfat of milk in a milk plant by the addition or removal of cream or skim milk.

6. The processing of foods and/or drinks other than Grade A milk and milk products are performed to preclude the contamination of such milk and milk products.

7. Means are provided to prevent contamination of milk containers, utensils, and equipment by drippings, spillage, and splash from overhead piping, platforms, or mezzanines.

8. All ingredients and nonproduct-contact materials used in the preparation or packaging of milk and milk products are stored in a clean place and are so handled as to prevent their contamination.

9. Pasteurized milk is not strained or filtered except through a perforated metal strainer. Multiple-use woven material shall not be used for straining milk.

Item 16p. Pasteurization. Pasteurization shall be performed as defined in Section 1, Definition (S), of this Ordinance.

Administrative Procedures. This item is deemed to be satisfied when:

1. All milk or milk products are heated to at least 145° F. and are held continuously at or above this temperature for at least 30 minutes, or to at least 161° F. and held continuously at or above this temperature for at least 15 seconds in properly designed and operated equipment which is approved by the health authority: Provided, That milk products which have a higher milkfat content than milk and/or contain added sweeteners shall be heated to at least 150° F. and held continuously at or above this temperature for at least 30 minutes, or to at least 166° F. and held continuously at or above this temperature for at least 15 seconds: Provided further, That nothing in this definition shall be construed as barring any other pasteurization process which has been recognized by the United States Public Health Service to be equally efficient and which is approved by the State health authority.

2. The design and the operation of pasteurization equipment and all appurtenances thereto comply with the applicable specifications and operational procedures of subitems (A) through (D), as follows:

16p(A). Batch Pasteurization. All indicating and recording thermometers used in connection with the batch pasteurization of milk or milk products shall comply with the applicable specifications.

1. Time and Temperature Controls for Batch Pasteurizers. a. Temperature Difference. —The pasteurizer shall be so designed that the simultaneous temperature difference between the milk or milk product at the center and the coldest milk or milk product in the vat will not exceed 1° F. at any time during the holding period.

The vat shall be provided with adequate agitation, operating throughout the holding period. No batch of milk or milk product shall be pasteurized unless it covers a sufficient area of the agitator to insure adequate agitation.

b. Location and Required Readings of Indicating and Recording Thermometers. — Each batch pasteurizer shall be equipped with both an indicating and a recording thermometer.

The thermometers shall read not less than the required pasteurization temperature throughout the required holding period. The plant operator shall check daily the temperature shown by the recording thermometer against the temperature shown by the indicating thermometer; this comparison shall be noted on the recording thermometer chart. The recording thermometer shall not read higher than the indicating thermometer. No batch of milk or milk products shall be pasteurized unless it be sufficient to cover the bulbs of both the indicating and the recording thermometers.

c. Insurance of Minimum Holding Periods. — Batch pasteurizers shall be so operated that every particle of milk or milk product will be held at not less than the minimum pasteurization temperature continuously for at least 30 minutes. When milk or milk products are raised to pasteurization temperature in the vat, and cooling is begun in the vat, simultaneously with or before the opening of the outlet valve, the recorder chart shall show at least 30 minutes at not less than minimum pasteurization temperature. When milk or milk products are preheated to pasteurization temperature before entering the vat, the recorder chart shall show a holding period of at least 30 minutes at not less than the minimum pasteurization temperature plus the time of filling from the level of the recorder bulb. When cooling is begun in the holder after the opening of the outlet valve, or is done entirely outside the holder, the chart shall show at least 30 minutes at not less than the minimum pasteurization temperature plus the time of emptying to the level of the recording-thermometer bulb.

When the recorder time interval on the recorder chart at the pasteurization temperature includes filling and/or emptying time, such intervals shall be indicated on the recorder chart by the operator, by removing the recording-thermometer bulb from the milk for a sufficient time to depress the pen, or by turning cold water into the vat jacket at the end of the holding period, or by inscribing the holding time on the chart. The filling time and the emptying time for each holder so operated shall be determined by the health authority, initially and after any change which may affect these times.

No milk shall be added to the holder after the start of the holding period.

2. Airspace Heating. a. Means shall be provided and used in batch pasteurizers to keep the atmosphere above the milk and milk products at a temperature not less than 5° F. higher than the minimum required temperature of pasteurization during the holding period.

b. Each batch pasteurizer shall be equipped with an airspace thermometer. The surface of the milk or milk product shall be at least 1 inch below the bottom of the thermometer bulb when the vat is in operation.

c. The temperature shown by the airspace thermometer shall be recorded on the recording thermometer chart each time the pasteurizer is in operation.

3. Inlet and Outlet Valves and Connections. a. The following definitions shall apply to inlet and outlet valves and connections:

(1) "Valve stop" shall mean a guide which permits turning the valve plug to, but not beyond, the fully closed position.

(2) "90° stop" shall mean a stop so designed as to prevent turning the plug more than 90°.

(3) "120° stop" shall mean a stop which prevents turning the plug more than 120°.

(4) "180° stop" shall mean a stop which prevents turning the plug more than 180°, but which permits two fully closed positions, each diametrically opposite the other.

(5) "Valve with an irreversible plug" shall mean one in which the plug cannot be reversed in the shell.

(6) "Single-quadrant stop" shall mean a 90° stop in a valve with an irreversible plug.

(7) "The fully open position" shall mean that position of the valve seat which permits the maximum flow into or out of the pasteurizer.

(8) "The closed position" shall mean any position of the valve seat which stops the flow of milk into or out of the pasteurizer.

(9) "The fully closed position" shall mean that closed position of the valve seat which requires the maximum movement of the valve to reach the fully open position.

(10) "The just-closed position" shall mean that closed position of a plug-type valve in which the flow into or out of the holder is barely stopped, or any closed position within five sixty-fourths inch thereof as measured along the maximum circumference of the valve seat.

(11) "Leakage" shall mean the entrance of unpasteurized milk into a batch pasteurizer during the holding or emptying period, or the entrance of unpasteurized milk into any pasteurized milk line at any time.

(12) "Leak-protector valve" shall mean a valve provided with a leak-diverting device, which, when the valve is in any closed position, will prevent leakage of milk past the valve or, in the case of batch pasteurizers filled or emptied by suction or compressed air, will prevent leakage of milk past the valve or the leakage of milk due to the leakage of air past the suction valve or the compressed air valve, as the case may be.

(13) "Closed-coupled valve" shall mean a valve, the seat of which is either flush with the inner wall of the pasteurizer, or so closely coupled that no milk in the valve inlet is more than 1^{o} F. colder than the milk at the center of the pasteurizer at any time during the holding period.

A close-coupled valve which is not truly flush, shall be considered as satisfying this requirement when (a) the vat outlet is so flared that the smallest diameter of the large end of the flare is not less than the diameter of the outlet line, plus the depth of the flare, and (b) the greatest distance from the valve seat to the small end of the flare is not greater than the diameter of the outlet line, and (c) in the case of batch pasteurizers, the outlet and the agitator are so placed as to insure that milk currents will be swept into the outlet.

4. Design and Installation of Valves and Connections. All valves and connections shall comply with the following requirements: a. Valves and pipeline connections shall meet the requirements of Item 10p.

b. All pipelines and fittings shall be so constructed and so located that leakage will not occur. Dependence shall not be placed on soldered joints to prevent leakage.

c. To prevent clogging, and to promote drainage, all leak-protection grooves shall be at least three-sixteenths inch wide, and at least three thirty-seconds inch deep at the center. Mating grooves shall provide these dimensions throughout their combined length whenever the valve is in, or approximately in, the fully closed position. All single-leak grooves, and all mating leak grooves when mated, shall extend throughout the entire depth of the seat, so as to divert leakage occurring at all points throughout the depth of the seat, and so as to prevent air bindings. Washers or other parts shall not obstruct leak-protector grooves.

d. A stop shall be provided on all plug-type outlet valves and on all plug-type inlet valves in order to guide the operator in closing the valve so that unpasteurized milk may not inadvertently be permitted to enter the outlet line or the holder, respectively. The stop shall be so designed that the plug will be irreversible when the plug is provided with any grooves or their equivalent, unless duplicate, diametrically opposite grooves be also provided. In the case of 2-way, plug-type valves (i. e., those having only one inlet and one outlet), a 180 degree stop, or any combination of stops permitting two fully closed positions, may be substituted for a 90 degree stop, provided that there be no air-relief grooves in the plug and that all leak grooves be located symmetrically with respect to the valve inlet. Stops shall be so designed that the operator cannot turn the valve beyond the stop position, either by raising the plug or by any other means.

e. Outlet valves, in addition to the requirements listed above, shall be so designed as to prevent the accumulation of unpasteurized milk in the milk passages of the valve when the valve is in any closed position.

f. All inlet pipelines and outlets from vat pasteurizers shall be equipped with leak-protector valves:

Provided, That installations not equipped with leak-protector inlet valves shall be accepted when the piping is so arranged that only one vat can be connected to the inlet line at a time, and such piping is disconnected during the holding and emptying periods.

g. Inlet and outlet connections other than through close-coupled valves shall not enter or leave the pasteurizer below the level of the milk therein.

h. In cases where the inlet line enters the holder above the milk level, and in which the inlet line may be submerged and thus prevent its complete emptying when the inlet valve is closed, the inlet line shall be provided with an automatic air-relief, or vent located either at the valve or elsewhere, and so designed as to function in every closed position of the valve. A vent may be provided by drilling a hole at least one-eighth inch in diameter in the vat pipe, below the vat cover, but above the maximum milk level.

i. All leak-protector valves shall be installed in the proper position to insure the function of the leak-diverting device. Inlet valves shall not be located in vertical pipelines, unless they can be so installed that one of the groove systems is at the lowest level of the valve; and pipelines between the inlet valve and the pasteurizer shall be as short as practicable and shall be sloped to drain.

j. All outlet valves shall be kept fully closed during filling, heating, and holding periods; and all inlet valves shall be kept fully closed during holding and emptying periods.

5. Recording Charts. All recording thermometer charts shall comply with all the applicable requirements herein.

Item 16p(B). High-Temperature, Short-Time, Continuous-Flow Pasteurization. (See HTST Pasteurization further along in this chapter.)

1. All indicating thermometers and recorder/controller instruments and devices used in connection with the high-temperature, short-time, continuous-flow pasteurization of milk or milk products shall comply with the applicable specifications set forth herein.

2. Each high-temperature, short-time, continuous-flow pasteurization system shall be equipped with an automatic milkflow control of the diversion type, which complies with the following definition, specifications, and performance requirements: a. The term automatic milkflow controls shall mean those safety devices which control the flow of milk in relation to the temperature of the milk, or heating medium and/or pressure, vacuum, or other auxiliary equipment. Milkflow controls shall not be considered as part of the temperature control equipment. Milkflow controls include (1) milk pump stops; (2) milk pump stops and spring-operated valves which automatically start and stop the flow of milk at legal and sublegal pasteurization temperatures, respectively; and (3) flow-diversion devices which automatically cause the diversion of the milk in response to a sublegal pasteurization temperature. At sublegal temperatures, flow-diversion devices return the milk to the raw milk side of the heating system continuously until legal pasteurization temperatures are obtained; at which time, the device restores forward-flow through the pasteurizer.

b. All flow-diversion valves and other milkflow stops used in continuous pasteurizers shall comply with the following or equally satisfactory specifications:

(1) Flow-Diversion Valves. — (a) Forward flow of subtemperature milk, due to the omission or looseness of the connecting clip, shall be prevented by making the valve and its actuating mechanism integral; or, where there is a connecting device, by making it impossible to assemble the valve and its actuating mechanism, except in such manner that it will function properly; or, where there is a connecting device which may be omitted or shaken loose by providing for pushing, instead of pulling, the valve to the diverted position; or by providing that the pump will shut down when the milk is below the pasteurization temperature and the valve is not in the fully diverted position; or by any other equally satisfactory means.

(b) It shall be impossible to tighten the stem packing to such an extent as to prevent the valve from assuming the fully diverted position.

(c) A leak escape shall be installed on the forward-flow side of the valve seat. However, when back pressure is exerted on the forward-flow side of the valve seat, while the milkflow is being diverted, the leak escape should lie between two valve seats, or between two portions of the same seat, one upstream and the other downstream from the leak escape. The leak escape shall be so designed and the valve so installed as to drain all leakage to the outside.

(d) The closure of the forward-flow seat shall be sufficiently tight so that leakage past it will not exceed the capacity of the leak escape device, as evidenced when the forward-flow line is disconnected; and, in order that proper seating may not be disturbed, the length of the connecting rod shall not be adjustable by the user.

(e) The flow-diversion valve shall be so designed and installed that failure of the primary motivating power shall automatically divert the flow of milk.

(f) The flow-diversion valve shall be located downstream from the holder. The flow-control sensor shall be located in the milk line not more than 18 inches upstream from the flow-control device.

(g) The pipeline from the diversion port of the flow-diversion valve shall be self-draining, and shall be free of restrictions or valves, unless such restrictions or valves be so designed that stoppage of the diversion line cannot occur.

(2) Milk-Flow Controller Instrumentation. — The following requirements shall be met with respect to the instrumentation of the milk-flow controller: (a) The thermal limit controller shall be set and sealed so that forward flow of product cannot start unless the temperature at the controller sensor be above 161° F. nor continue during descending temperatures when the temperature is below 161° F. The seal shall be applied by the health authority after test, and shall not be removed without immediately notifying the health authority. The system shall be so designed that no milk can be bypassed around the controller sensor which shall not be removed from its proper position during the pasteurization process. The cut-in and cut-out milk temperatures, as shown by the indicating thermometer, shall be determined at the beginning of each day's operation and entered upon the recorder chart daily by the plant operator.

(b) Manual switches for the control of pumps, homogenizers, or other devices which produce flow through the holder, shall be wired so that the circuit is completed only when the milk is above 161° F. or when the diversion valve is in the fully diverted position.

(3) Holding Tube. —(a) Holders shall be designed to provide for the holding of every particle of milk or milk product for at least 15 seconds.

(b) The holder shall be so designed that the simultaneous temperature difference between the hottest and coldest milk in any cross section of flow at any time during the holding period will not be greater than 1° F. This requirement may be assumed to have been satisfied without test in tubular holders of 7 inches or smaller diameter which are free of any fittings through which the milk may not be thoroughly swept.

(c) No device shall be permitted for short circuiting a portion of the holder to compensate for changes in rate of milkflow. Holding tubes shall be installed so that sections of pipe cannot be left out, resulting in a shortened holding time.

(d) The holding tube shall be arranged to have a continuously upward slope in the direction of flow of not less than one-fourth inch per foot.

(e) Supports for tubes shall be provided to maintain all parts of holding tubes in a fixed position, free from any lateral or vertical movement.

(f) The holder shall be so designed that no portion between the inlet and the flow-control temperature sensor is heated.

(4) Indicating and Recording Thermometers. — (a) An indicating thermometer shall be located as near as practicable to the temperature sensor of the recorder controller, but may be located a short distance upstream from the latter where milk between the two thermometers does not differ significantly in temperature.

(b) The temperature shown by the recorder controller shall be checked daily by the plant operator against the temperature shown by the indicating thermometer. Readings shall be recorded on the chart. The recorder controller shall be adjusted to read no higher than the indicating thermometer.

(c) The recorder controller charts shall comply with the applicable provisions herein.

(5) Flow-Promoting Devices.—(a) The pump, or pumps, and other equipment which may produce flow through the holder shall be located upstream from the holder, provided that pumps and other flow-promoting devices may be located downstream from the holder if means be provided to eliminate negative pressure between the holder and the inlet to such equipment. When vacuum equipment is located downstream from the holder, an effective vacuum breaker, plus an automatic means of preventing a negative pressure in the line between the flow-diversion valve and the vacuum chamber, shall be acceptable.

(b) The speed of pumps or other flow-promoting devices governing the rate of flow through the holder shall be so controlled as to insure the holding of every particle of milk for at least 15 seconds. In all cases, the motor shall be connected to the metering pump by means of a common driveshaft, or by means of gears, pulleys, or a variable-speed drive, with the gear box, the pulley box, or the setting of the variable-speed protected in such a manner that the holding time cannot be changed without detection by the health authority. This shall be accomplished by the application of a suitable seal(s) after tests by the health authority and such seal shall not be broken without immediately notifying the health authority. The provision shall

apply to all homogenizers used as timing pumps.

Variable-speed drives used in connection with the metering pump shall be so constructed that wearing or stretching of the belt results in a slowdown, rather than a speedup, of the pump.

The metering or timing pump shall be of the positive displacement type.

(c) The holding time shall be taken to mean the flow time of the fastest particle of milk, at or above 161° F., throughout the holder section; i.e., that portion of the system that is outside of the influence of the heating medium, and slopes continuously upward in the downstream direction, and is located upstream from the flow-diversion valve. Tests for holding time shall be made when all equipment and devices are operated and adjusted to provide for maximum flow. When a homogenizer is located upstream from the holder, the holding time shall be determined with the homogenizer in operation with no pressure on the homogenizer valves. Where bypass lines are provided, either upstream or downstream from the metering pump, the holding time shall be tested with both the regular and bypass line open, unless the bypass valve be so designed that both lines cannot be open at the same time.

The holding time shall be tested during both forward and diverted flow. If necessary to lengthen the holding time during diverted flow, an identifiable restriction may be placed in the vertical portion of the diversion pipeline.

When vacuum equipment is located downstream from the holder, the holding time shall be tested with the metering pump operating at maximum flow, and the vacuum equipment adjusted to provide for the maximum vacuum.

The holding time shall be tested in both forward and diverted flow by the health authority initially, semiannually thereafter, after any alteration or replacement that may affect the holding time, and whenever the seal of the speed setting has been broken.

(6) Prevention of Product Adulteration With Added Water. — (a) When culinary steam is introduced directly into the milk or milk product downstream from the flow-diversion valve, means shall be provided to preclude the addition of steam to the product, unless the flow-diversion valve be in the forward-flow position. This provision may be satisfied by the use of an automatic steam control valve with temperature sensor located downstream from the steam inlet, or by the use of an automatic solenoid valve installed in the steam line and so wired through the flow-diversion valve controls that steam cannot flow unless the flow-diversion valve be in the forward-flow position.

(b) When culinary steam is introduced directly into the milk or milk product, automatic means shall be provided to maintain a proper temperature differential between incoming and outgoing milk to preclude dilution with water.

(c) Where a water feed line is connected to a vacuum condenser and the vacuum condenser is not separated from the vacuum chamber by a physical barrier, means shall be provided to preclude the backup and overflow of water from the vacuum condenser to the vacuum chamber. This provision may be satisfied by the use of a safety shutoff valve, located on the water feed line to the vacuum condenser, automatically actuated by a control which will shut off the inflowing water, if for example, the condensate pump stops and the water level rises above a predetermined point in the vacuum condenser. This valve may be actuated by water, air, or electricity, and shall be so designed that failure of the primary motivating power will automatically stop the flow of water into the vacuum condenser.

Item 16p (C). Pasteurizers Employing Milk-to-Milk Regenerative Heating. (See figures 2, 3, 4, and 5.) Pasteurizers employing milk-to-milk regenerative heating with both sides closed to the atmosphere shall comply with the following or equally satisfactory specifications:

1. Regenerators shall be constructed, installed, and operated so that pasteurized milk in the regenerator will automatically be under greater pressure than raw milk in the regenerator at all times.

2. The pasteurized milk, between its outlet from the regenerator and the nearest point downstream open to the atmosphere, shall rise to a vertical elevation of 12 inches above the highest raw milk level downstream from the constant-level tank and shall be open to the atmosphere at this or a higher elevation.

3. The overflow of the top rim of the constant-level raw milk tank shall always be lower than the lowest milk level in the regenerator.

4. No pump or flow-promoting device which can affect the proper pressure relationships within the regenerator shall be located between the pasteurized milk outlet from the regenerator and the nearest downstream point open to the atmosphere.

5. No pump shall be located between the raw milk inlet to the regenerator and the raw milk supply tank, unless it be designed and installed to operate only when milk is flowing through the pasteurized milk side of the regenerator, and when the pressure of the pasteurized milk is higher than the maximum pressure produced by the pump. This may be accomplished by wiring the booster pump so that it cannot operate unless (a) the metering pump be in operation, (b) the flow-diversion valve be in forward-flow position, and (c) the pasteurized milk pressure exceeds, by at least 1 pound per square inch, the maximum pressure developed by the booster pump. Pressure gages shall be installed at the raw milk inlet to the regenerator and the pasteurized milk outlet of the regenerator or the outlet of the cooler. The accuracy of required pressure gages shall be checked by the health authority on installation, quarterly thereafter, and following repair or adjustment (see Test 9).

6. The motor, casing, and impeller of the booster pump shall be identified, and such records thereof maintained as directed by the health authority.

7. All raw milk in the regenerator will drain freely back into the constant-level raw milk tank when the raw milk pump(s) are shut down and the raw milk outlet from the regenerator is disconnected.

8. When vacuum equipment is located downstream from the flow-diversion valve, means shall be provided to prevent the lowering of the pasteurized milk level in the regenerator during periods of diverted flow or shutdown. An effective vacuum breaker, plus an automatic means of preventing a negative pressure, shall be installed in the line between the vacuum chamber and the pasteurized milk inlet to the regenerator.

Item 16p (D). Temperature Recording Charts Equipment Tests and Examinations.

1. All temperature recording charts shall be preserved for a period of 3 months. The use of such charts shall not exceed the time limit for which they are designed. Overlapping of recorded data shall be a violation of this item. The following information shall be entered on the charts as applicable:

(a) Batch Pasteurizers: (1) Date.

(2) Number or location of recorder when more than one is used.

(3) Extent of holding period, including filling and emptying times when required (Item 16p(A)).

(4) Reading of airspace thermometer within the holding period at a given time or reference point as indicated on the chart (Item 16p(A)).

(5) Reading of indicating thermometer within the holding period at a given time or reference point as indicated on the chart (Item 16p(A)).

(6) Quarterly, the initials of the health authority opposite the required readings of the indicating thermometer and airspace thermometer (Item 16p(A)).

(7) Quarterly, the time accuracy of the recorder, as determined by the health authority (Test 3).

(8) Amount and name of pasteurized milk or milk product represented by each batch or run on the chart.

(9) Record of unusual occurrences.

(10) Signature or initials of operator.

(11) Name of milk plant.

(b) High-Temperature, Short-Time Pasteurizers. — Recording thermometer charts shall contain all the information specified in (a) above, except (3) and (4), and in addition, shall include the following:

(1) A record of the time during which the milkflow diversion valve is in the forward flow position.

(2) The cut-in and cut-out milk temperatures recorded daily by the operator at the beginning of the run, and initialed quarterly by the health authority (Item 16p(B)). (The recorded temperature shown on the controller chart shall be used to determine that the required temperature for milk products containing higher fat and/or sweeteners has been achieved.)

2. Equipment Tests and Examinations. — The health authority shall perform the indicated tests on the following instruments and devices initially on installation, and at least once each 3 months thereafter, and whenever any alteration or replacement is made which may affect the proper operation of the instrument or device: Provided, That the holding time test shall be conducted semiannually.

Instrument or device	Test No.	Test objective
Batch pasteurizer indicating thermometer	1	Accuracy.
Batch pasteurizer recording thermometer	2	Temperature accuracy.
	3	Time accuracy.
	4	Check reading of recording thermometer against indicating thermometer.
Airspace thermometer	1	Accuracy.
Valves	6	Leakage in plug type leak-protector valves and poppet type valves.
HTST indicating thermometer	1	Accuracy.
	7	Thermometric response.
HTST recording thermometer	2	Temperature accuracy.
	3	Time accuracy.
HTST recorder controller	2	Temperature accuracy.
	4	Check reading of recorder controller against indicating thermometer.
	8	Thermometric response.
	10	Confirm cut-in and cut-out temperatures.
HTST flow diversion valve	5	Assembly and function.
HTST auxiliary (booster) pump	9	Function of automatic control devices.
	9	Accuracy of pressure gauges.
HTST systems	11	Check holding time.

Item 17p. Cooling of Milk. All raw milk and milk products shall be maintained at 50° F. or less until processed. All pasteurized milk and milk products, except those to be cultured, shall be cooled immediately in approved equipment to a temperature of 45° F. or less. All pasteurized milk and milk products shall be stored at a temperature of 45° F. or less and be maintained thereat until delivered. Every room or tank in which milk or milk products are stored shall be equipped with an accurate thermometer.

Administrative Procedures. This item is deemed to be satisfied when:

1. All raw milk and milk products are maintained at 50° F. or less until processed.

2. All pasteurized milk and milk products, except those to be cultured, are cooled immediately in approved equipment to a temperature of 45° F. or less. All pasteurized milk and milk products shall be stored at a temperature of 45° F. or less and be maintained thereat until delivered.

3. Each refrigerator room in which milk or milk products are stored is equipped with a thermometer which complies with the applicable specifications. Such thermometer shall be located in the warmest zone of the refrigerator room.

Each storage tank shall be equipped with a thermometer, the sensor of which shall be located to permit the registering of the temperature of the contents when the tank contains no more than 20 percent of its calibrated capacity. Such thermometer shall comply with the applicable specifications.

4. All surface coolers comply with the following specifications: a. The sections of

open-surface coolers shall be so installed as to leave a gap of at least one-quarter inch between the header sections to permit easy cleaning.

b. Where header ends are not completely enclosed within the cooler covers, condensation or leakage from the headers shall be prevented from entering the milk or milk products by so shaping the exposed header faces, above and below all gaps, that condensation is directed away from the tubes, and by using deflectors at the bottom of the headers, or by shortening the bottom trough, or by some other approved method.

c. The location of supports of cooler sections shall prevent drip from entering the milk or milk products.

d. All open surface coolers shall be provided with tight-fitting shields which protect the milk and milk products from contamination by flies, dust, drip, splash, or manual contact.

5. Recirculated cold water which is used in coolers and exchangers is from a safe source and protected from contamination. Such water shall be tested semiannually and shall comply with the bacteriological standards. Recirculated water systems which become contaminated through repair work or otherwise shall be properly treated and tested before being returned to use. Freezing point depressants, when used in recirculating systems, shall be nontoxic.

Item 18p. Bottling and Packaging. Bottling and packaging of milk and milk products shall be done at the place of pasteurization in approved mechanical equipment.*

Administrative Procedures.** This item is deemed to be satisfied when:

1. All milk and milk products, including concentrated milk and milk products are bottled and packaged at the plant where final pasteurization is performed. Such bottling and packaging shall be done without undue delay following final pasteurization.

2. All bottling or packaging is done on approved mechanical equipment. The term "approved mechanical equipment" shall not be interpreted to exclude manually operated machinery but is interpreted to exclude methods in which the bottling and capping devices are not integral in one system.

3. Bottling or packaging machines are designed to minimize the need for adjustment during operation. All pipes, connections, defoaming devices, and similar appurtenances shall comply with Items 10p and 11p.

4. Bottling or packaging machine supply tanks and bowls have covers which are constructed to prevent any contamination from reaching the inside of the filler tank or bowl. All covers shall be in place during operation.

5. A drip deflector is installed on each filler valve. Such drip deflector shall be designed and adjusted to divert condensation away from the open container.

6. Container infeed conveyors to automatic bottling or packaging machines have overhead shields to protect the bottles or packages from contamination. Such shields shall extend from the bottle washer discharge to the bottle feed star or, in the case of single service packaging machines, from the forming unit discharge to the filling unit and from the filling unit to

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* Communities desiring to regulate the sale of cottage cheese and creamed cottage cheese under the terms of this Ordinance should add the following: Provided, That cottage cheese and creamed cottage cheese may be transported in sealed containers in a protected, sanitary manner from one plant to another for creaming and/or packaging.

** Communities desiring to regulate the sale of cottage cheese and creamed cottage cheese under the terms of this Ordinance should add the following to the Administrative Procedures of Item 18p:

"Cottage cheese and creamed cottage cheese are protected in a sanitary manner; they may be transported in sealed containers from one plant to another for creaming and/or packaging."

the closure unit. Overhead shields shall be required on can infeed conveyors when the cans are fed to the filler with covers off.

7. Container fabricating materials, such as paper stock, foil, wax, plastic, etc., are handled in a sanitary manner and protected against undue exposure during the package assembly operation.

8. Bottling and packaging machine floats are designed to be adjustable without removing the cover.

9. The filler pipe of all bottling and packaging machines have an apron or other approved device as close to the filler bowl as possible to prevent condensation or drip from reaching the inside of the filler bowl.

10. Filling cylinders on packaging machines are protected from contamination by the use of overhead shields. When any lubricant is applied to the filler pistons, cylinders, or other milk contact surfaces, the lubricant shall be nontoxic, sterile, and shall be sparingly applied in a sanitary manner.

Item 19p. Capping. Capping or closing of milk and milk product containers shall be done in a sanitary manner by approved mechanical capping and/or closing equipment. The cap or closure shall protect the pouring lip to at least its largest diameter.

Administrative Procedures.* This item is deemed to be satisfied when:

1. The capping or closing of milk and milk product containers is done in a sanitary manner on approved mechanical capping/closing equipment. The term "approved mechanical capping and/or closing equipment" shall not exclude manually operated machinery. Handcapping shall be prohibited: Provided, That if suitable mechanical equipment for the capping or closing of specific container(s) of 3 gallons or more not be available, other methods which eliminate all possibility of contamination may be approved by the health authority.

2. All mechanical capping or closure mechanisms are designed to minimize the need for adjustment during operation.

3. Bottles and packages which have been imperfectly capped or closed are emptied immediately into approved sanitary containers. Such milk or milk products shall be protected from contamination, maintained at 45° F. or less, and subsequently repasteurized or discarded.

4. All caps or closures protect the pouring lip of multiuse containers to at least the greatest diameter. Single-service containers shall be so constructed that the product and the pouring and opening areas are protected from contamination during handling, storage, and when the containers are initially opened.

5. Caps and closures are handled in a sanitary manner. The first cap from each tube, the first lap(s) from each roll of cap or cover stock, and the first sheet of parchment or cover

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* Communities desiring to regulate the sale of cottage cheese and creamed cottage cheese under the terms of this Ordinance should add the following to the indicated administrative procedures of Item 19p:

1. Provided further, That if suitable equipment be not available for capping cottage cheese and creamed cottage cheese, other methods of capping which eliminate possible chance of contamination may be approved by the health authority.

4. Closures for cottage cheese and creamed cottage cheese containers shall extend over the top edges of the container so as to protect the product from contamination during subsequent handling.

5. Provided, That this requirement(s) shall not apply to cottage cheese and creamed cottage cheese container closures, when such closures are supplied in a totally enclosed package, or wrapped so as to protect the closures.

paper shall be discarded. The subsequent use of loose caps which are left in the cappers at the end of an operating period after removal from the cap tubes shall be a violation of this item.

Item 20p. Personnel—Cleanliness. Hands shall be thoroughly washed before commencing plant functions and as often as may be required to remove soil and contamination. No employee shall resume work after visiting the toilet room without thoroughly washing his hands. All persons engaged in the processing, pasteurization, handling, storage, or transportation of milk, milk products, containers, equipment,and utensils shall wear clean outer garments. The use of tobacco by any person engaged in the processing of milk or milk products is prohibited.

Administrative Procedures. This item is deemed to be satisfied when:

1. Hands are thoroughly washed before commencing plant functions and as often as may be required to remove soil and contamination.

2. Each employee washes his hands following a visit to the toilet room and prior to resuming work.

3. All persons engaged in the processing, pasteurization, handling, storage, or transportation of milk, milk products, containers, equipment, and utensils wear clean outer garments.

4. Tobacco is not used by any person while engaged in the processing of milk or milk products.

Item 21p. Vehicles. All vehicles used for transportation of pasteurized milk and milk products shall be constructed and operated so that the milk and milk products are maintained at 45° F. or less, and are protected from sun, from freezing, and from contamination.

Administrative Procedures. This item is deemed to be satisfied when:

1. All vehicles are kept clean.

2. Material which is capable of contaminating milk or milk products is not transported with milk or milk products.

3. Vehicles have fully enclosed bodies with well-fitted solid doors.

Item 22p. Surroundings. Milk plant surroundings shall be kept neat, clean, and free from conditions which might attract or harbor flies, other insects and rodents, or which otherwise constitute a nuisance.

Administrative Procedures. This item is deemed to be satisfied when:

1. There is no accumulation of trash, garbage, or similar waste in areas adjacent to the milk plant. Waste material stored in suitable covered containers shall be considered in compliance.

2. Driveways, lanes, and areas serving milk plant vehicular traffic are graded, drained, and free from pools of standing water.

3. Outdoor areas for transport tank unloading are constructed of smooth concrete or equally impervious material, properly sloped to drain, and equipped with trapped drains of sufficient size.

4. Only pesticides approved for use by the health authority and/or registered with the U.S. Department of Agriculture shall be used for insect and rodent control.

Section 8. Animal Health. All milk for pasteurization shall be from herds which are located in a Modified Accredited Tuberculosis Area as determined by the U.S. Department of Agriculture: Provided, That herds located in an area that fails to maintain such accredited status

shall have been accredited by said Department as tuberculosis free, or shall have passed an annual tuberculosis test.

All milk for pasteurization shall be from herds under a brucellosis eradication program which meets one of the following conditions:

1. Located in a Certified Brucellosis-Free Area as defined by the U.S. Department of Agriculture and enrolled in the testing program for such areas; or

2. Located in a Modified Certified Brucellosis Area as defined by the U.S. Department of Agriculture and enrolled in the testing program for such areas; or

3. Meet U.S. Department of Agriculture requirements for an individually certified herd; or

4. Participating in a milk ring testing program which is conducted on a continuing basis at intervals of not less than every 3 months or more than every 6 months, with individual blood tests on all animals in herds showing suspicious reactions to the milk ring test; or

5. Have an individual blood agglutination test annually with an allowable maximum grace period not exceeding 2 months.

For diseases other than brucellosis and tuberculosis, the health authority shall require such physical, chemical, or bacteriological tests as he deems necessary. The diagnosis of other diseases in dairy cattle shall be based upon the findings of a licensed veterinarian or a veterinarian in the employ of an official agency. Any diseased animal disclosed by such test(s) shall be disposed of as the health authority directs.

Administrative Procedures

Tuberculosis. All tuberculin tests and retests shall be made, and any reactors disposed of, in accordance with the Uniform Methods and Rules for establishing and maintaining of Tuberculosis-Free Accredited Herds of Cattle and Modified Accredited Areas, as approved by the USDA at the time of the adoption of this Ordinance. For tuberculosis test purposes, the herd is defined as all adult cattle 24 months of age and over, including any commingled beef animals. Dairy cattle less than 2 years of age and already milking, shall be included in the herd test. A letter or other official correspondence attesting to the accreditation status of the locality in which the herd is located, including the date of accreditation, or a certificate identifying the animals tested, the date of injection, the date of reading of the test, and the results of the test signed by a U.S. Department of Agriculture accredited veterinarian, shall be evidence of compliance with the above requirements and shall be filed with the health authority.

Brucellosis. All brucellosis tests, retests, disposal of reactors, vaccination of calves, and certification of herds and areas shall be in accordance with the recommended Uniform Methods and Rules for brucellosis eradication. All reactors disclosed on blood agglutination tests shall be separated immediately from the milking herd; the milk of these reactors shall not be used for human consumption.

A certificate identifying each animal, signed by the veterinarian and the director of the laboratory making the test, shall be filed as directed by the health authority: Provided, That in the event the herd be subject to the milk ring test, the record shall be required to show only the date and results of such test. Within 30 days following the expiration of an official milk ring testing program or, in the case of a herd subject to annual blood tests, 13 months following the last annual blood test, the health authority shall notify the herd owner or operator of the necessity to comply with the brucellosis requirements. The failure of the herd owner or operator to comply with the brucellosis requirements within 30 days of written notice shall result in immediate suspension of the permit.

Section 9. Milk and Milk Products Which May Be Sold. From and after 12 months from the

date on which this Ordinance is adopted, only Grade A pasteurized milk and milk products* shall be sold to the final consumer, or to restaurants, soda fountains, grocery stores, or similar establishments: Provided, That in an emergency, the sale of pasteurized milk and milk products which have not been graded, or the grade of which is unknown, may be authorized by the health authority; in which case, such milk and milk products shall be labeled "ungraded".

Section 10. Transferring; Delivery Containers; Cooling. Except as permitted in this section, no milk producer or distributor shall transfer milk or milk products from one container or tank truck to another on the street, in any vehicle, store, or in any place except a milk plant, receiving station, transfer station, or milkhouse especially used for that purpose. The dipping or ladling of milk or fluid milk products is prohibited.

It shall be unlawful to sell or serve any milk or fluid milk product except in the individual, original container received from the distributor, or from an approved bulk dispenser: Provided, That this requirement shall not apply to milk for mixed drinks requiring less than one-half pint of milk, or to cream, whipped cream, or half-and-half which is consumed on the premises and which may be served from the original container of not more than one-half gallon capacity, or from a bulk dispenser approved for such service by the health authority.

It shall be unlawful to sell or serve any pasteurized milk or milk product which has not been maintained at a temperature of 45° F. or less. If containers of pasteurized milk or milk products be stored in ice, the storage container shall be properly drained.

Administrative Procedures

Transferring. The dipping or ladling of milk and fluid milk products is expressly prohibited, except for immediate cooking purposes. Milk and milk product containers which have been filled and sealed at a milk plant shall be used for the delivery of milk or milk products. Caps, closures, or labels shall not be removed or replaced during transportation.

Bulk Dispensers. Bulk dispensers, approved by the health authority, shall satisfy the following sanitary design, construction, and operation requirements:

1. All dispensers shall comply with the applicable requirements of Section 7 of this Ordinance.

2. Product-contact surfaces shall be inaccessible to manual contact, droplet infection, dust, or flies; but the delivery orifice may be exempted from this requirement.

3. All parts of the dispensing device with which milk or milk products come into contact, including any measuring device, shall be thoroughly cleaned and sanitized at the milk plant: Provided, That dispensing valves which are applied to the dispenser subsequent to its delivery to the retail vendor may be cleaned and sanitized at such establishments.

4. The dispensing container shall be filled at the milk plant and shall be so sealed that it is impossible to withdraw any part of its contents, or to introduce any substance without breaking the seal(s).

5. The milk or milk products shall be thoroughly and automatically mixed with each dispensing operation, except for milk or milk products which remain homogeneous.

6. All cans shall be thoroughly cleaned and sanitized. Milk and milk products shall be kept at or below 45° F. at all times. The dispenser tube shall be integral with the dispensing

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* Communities wishing to provide for the sale of certified pasteurized milk should include such product in this section.

Note. Certified pasteurized milk is derived from certified raw milk which meets the latest requirements of the American Association of Medical Milk Commissions, Inc., 405 Lexington Ave., New York, N.Y., 10017.

container, shall be protected, and shall be under adequate refrigeration during transportation and storage.

Section 11. Milk and Milk Products From Points Beyond the Limits of Routine Inspection. Milk and milk products from points beyond the limits of routine inspection of the _____ of _____,[1] or its police jurisdiction, may be sold in _____,[1] or its police jurisdiction, provided they be produced and pasteurized under regulations which are substantially equivalent to this Ordinance and have been awarded an acceptable milk sanitation compliance and enforcement rating made by a State milk sanitation rating officer certified by the U.S. Public Health Service.

Administrative Procedures. The health authority should accept, without his actual physical inspection, supplies of milk and milk products from an area or an individual shipper not under his routine inspection: Provided, That (1) upon arrival, each shipment of raw milk for pasteurization shall comply with the bacteriological, chemical, and temperature standards of Section 7; (2) after receipt, pasteurized milk and milk products shall comply with the bacteriological, chemical, and temperature requirements of Section 7 as determined in accordance with Section 6; (3) the milk or milk products are produced and processed under regulations substantially equivalent to those of this Ordinance; (4) the supplies are under routine official supervision; (5) the supplies have been awarded, by the State milk sanitation rating officer certified by the U.S. Public Health Service, a milk sanitation compliance and enforcement rating equal to that of the local supply or equal to 90 percent or higher; and (6) all ratings are made on the basis of procedures outlined in methods of making sanitation ratings of milksheds recommended by the Public Health Service.

Section 12. Future Dairy Farms and Milk Plants. Properly prepared plans for all milk houses, milking barns, stables and parlors, transfer stations, receiving stations, and milk plants regulated under this Ordinance which are hereafter constructed, reconstructed, or extensively altered, shall be submitted to the health authority for written approval before work is begun.

Section 13. Personnel Health. No person affected with any disease in a communicable form, or while a carrier of such disease, shall work at any dairy farm or milk plant in any capacity which brings him into contact with the production, handling, storage, or transportation of milk, milk products, containers, equipment, and utensils; and no dairy farm or milk plant operator shall employ in any such capacity any such person, or any person suspected of having any disease in a communicable form, or of being a carrier of such disease. Any producer or distributor of milk or milk products, upon whose dairy farm, or in whose milk plant any communicable disease occurs, or who suspects that any employee has contracted any disease in a communicable form, or has become a carrier of such disease, shall notify the health authority immediately.

Section 14. Procedure When Infection is Suspected. When reasonable cause exists to suspect the possibility of transmission of infection from any person concerned with the handling of milk and/or milk products, the health authority is authorized to require any or all of the following measures: (1) the immediate exclusion of that person from milk handling; (2) the immediate exclusion of the milk supply concerned from distribution and use; and (3) adequate medical and bacteriological examination of the person, of his associates, and of his and their body discharges.

Section 15. Enforcement. This Ordinance shall be enforced by the health authority in accord-

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Note. Names of Interstate milk shippers and their ratings, as reported by State milk control authorities, are contained in Sanitation Compliance and Enforcement Ratings of Interstate Milk Shippers, issued quarterly by the Public Health Service for the information of interested persons. Copies of this list may be obtained from the State milk control authority or from the Public Health Service, Washington, D.C., 20201.

1. See footnote 1.

ance with the Grade A Pasteurized Milk Ordinance with Administrative Procedures—1965 Recommendations of the United States Public Health Service, a certified copy[5] of which shall be on file at the municipal clerk's office.[1] Where the mandatory compliance with provisions of the appendixes is specified, such provisions shall be deemed a requirement of the Ordinance.

Section 16. Penalty. Any person who shall violate any of the provisions of this Ordinance shall be guilty of a misdemeanor and, upon conviction thereof, shall be punished by a fine of not more than $_____, and/or such persons may be enjoined from continuing such violations. Each day upon which such a violation occurs shall constitute a separate violation.

Section 17. Repeal and Date of Effect. All ordinances and parts of ordinances in conflict with this Ordinance shall be repealed 12 months after the adoption of this Ordinance, at which time this Ordinance shall be in full force and effect, as provided by law.

Section 18. Unconstitutionality Clause. Should any section, paragraph, sentence, clause, or phrase, of this Ordinance be declared unconstitutional or invalid for any reason, the remainder of this Ordinance shall not be affected thereby.

Dairy - Construction and Operation

Milking Barn, Stable, and Parlor

Numerous factors, including the size and topography of the farm, the availability of utilities, the condition and disposition of existing buildings, the dairyman's ultimate goals for his enterprise, and his construction budget serve to make each milk producer's herd housing problems individual and unique.

While there has been a tendency for workers to develop strong convictions about the practicability of given housing or milking systems, there is little doubt that the success or failure of most dairy farm operations may be traced to good or poor planning. When the unique problems of each system in its individual application are given proper consideration, the job of producing clean milk is made easier and compliance with regulations is simplified. For example, operators of barns in which cows are housed and milked will find that efficient ventilation not only reduces condensation, but also relieves the problem of dust and mold on walls, ceilings, and windows. When window sills are sloped or windows set flush with interior walls in stanchion barns, the accumulation of dust and unwanted miscellaneous items is similarly lessened. Covered recessed light fixtures remain clean longer and are less subject to damage than those projecting from the ceiling.

Operators of milking parlor loose-housing systems, on the other hand, will value design features such as mechanically operated doors which speed up animal traffic, and glazed wall finishes which cut down the time required for proper post-milking wash up of the parlor. Cleaner cows result from proper planning and management of exercise yards and bedded areas. One hundred square feet of surfaced yard and not less than 50 square feet of bedded space are recommended for each animal to be accommodated. Provisions must also be made for the removal at least daily of manure from exercise yards and traffic lanes. Operators utilizing loose-housing have shown considerable interest recently in free-stall housing. Many workers have concluded that it provides the solution of the problems of unclean cows and excessive bedding demands which have plagued loose-housing in past years. Its features should be carefully studied by milk producers planning new construction or large-scale changes in existing housing.

Adequate light must be available in all work areas in the milking barn, stable, or parlor. Because many dairy functions are frequently performed after dark, it is important that the required minimum of 10 foot-candles of illumination be available from artificial sources. While absolute certainty of compliance with this requirement can only be confirmed by the use

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1. See footnote 1.

5. A certified copy may be secured from the Department of Health, Education, and Welfare, Public Health Service, Washington, D. C.

of a light meter, experience has shown that milking barns which otherwise meet the standards of the PHS Ordinance will be properly lighted when equipped with one 100-watt bulb (or its fluorescent equal) for each three stanchions or per 10 linear feet of walkway behind each row of cows in face-in barns or between rows of cows in face-out barns. In addition, a smaller number of bulbs, equally spaced, is recommended for feed alleys in front of cows. When natural light is utilized, a minimum of 4 square feet of window space for each 60 square feet of floor space is recommended.

Construction plans and suggestions for the various systems of animal management are available to the sanitarian and the dairyman from numerous sources, including the USDA, the county extension agent, farm periodicals, and the trade associations serving the building supply industry.

Milkhouse or Milkroom

Milkhouses should be large enough to provide adequate space to meet present needs and should take into account the prospect of future expansion. Installed milkroom equipment should be readily accessible to the operator. Aisles should be at least 30 inches wide, with added allowance at the outlets of bulk cooling/holding tanks, adjacent to wash and rinse vats, and where operational conditions warrant. It is especially important that the space available to bulk cooling/holding tanks and CIP (cleaning-in-place) systems be adequate to permit their disassembly, inspection, and servicing.

Floor drains should not be located under bulk cooling/holding tanks unless there be sufficient room for servicing. Floor drains should not be located directly under the outlet of a bulk cooling/holding tank. Drains and waste disposal systems should be adequate to drain the volume of water used in rinsing and cleaning.

Milkrooms should be well ventilated. Proper ventilation not only avoids the obvious disadvantages of condensation on equipment and walls; it also lengthens the useful life of the building and its equipment. The constant need for renewal of painted surfaces, the repair of wooden fixtures and frames, and the removal of algae and mold from walls and ceilings of poorly ventilated milkrooms can represent a continuing expense to the operator.

Where possible, windows should be placed to provide cross ventilation. In addition, one or more ceiling vents should be located to receive water vapor rising from wash-and-rinse vats and other sources of evaporative moisture.

Glass brick is sometimes substituted for windows in milkroom construction. In these instances, mechanical ventilation must be provided. A system affording filtered positive air pressure is recommended over exhaust ventilation, as the latter frequently draws dust, insects, and odors into the milkroom.

The great demand for water under pressure in milkroom operations has emphasized the importance of protecting plumbing from freezing. Devices which have proved effective include the insulation of water lines, the use of wrap-around heat tape, infrared lamps, and thermostatically controlled space heaters.

Insulated milkrooms make protection against freezing easier and more economical, and offer the additional advantage of greater comfort for the operator. The factor of personal convenience frequently results in better performance by the operator, with consequent benefits to milk quality.

Automated milking and CIP (cleaning-in-place) cleaning of milking equipment has increased the use of hot water in the milkroom. The following table will indicate the volumes of water required to fill 100 feet of pipelines of varying diameters:

Pipe Diameter	Gallons
Inches	
1	4.7
1-1/2	9.2
2	16.3

Since most CIP installations employ a prerinse, followed by wash-and-rinse cycles, this figure actually represents only one-third the usual milking-time demand for heated water. Also, it does not include the "take-up" of collecting jars, pumps, rubber parts, etc.

Udder washing, bulk cooling/holding tank cleaning, and similar milkroom tasks offer additional uses for hot water.

Sanitarians should compute the hot water demand of the individual milking systems under their supervision and require that not less than the minimum amount be available at all times. Milk producers should be made aware of the fact that effective cleaning of CIP installations is impossible without adequate hot water and should be encouraged to provide a supply which exceeds their expected need. Such planning avoids emergency shortages and allows for normal expansion of the herd and facilities.

Detailed plans for milkhouses, as well as recommendations on hot water needs, insulation, lighting, and ventilation are available from power companies, building supply associations, county extension agents, and State universities.

Refrigeration, electrical or mechanical systems powered by gasoline or diesel engines, have no place in a milkroom, milking barn, or in any communicating passageway between the milkroom and milking barn. Such equipment is characteristically given to oil leakage and the discharge of fumes. The spaces occupied by it are difficult to keep clean and frequently become gathering places for trash and flammable materials. With effective planning, these engines and their accessory equipment can be located, without detriment to their performance, in a separate room or building adjacent to the barn or milkhouse.

Milking Methods

Milking methods must be geared to permit the efficient withdrawal of milk without introducing undue numbers of bacteria or causing injury to the udder.

In addition to assessing the Nation's milk producers a cost which has been estimated to approach $500 million annually, mastitis has been found to pose serious public health hazards. The most widespread of these is a gastrointestinal disorder caused by toxins produced by certain strains of staphylococci.

It has been known for many years that a relationship exists between mastitis and milking practices. While not all the facts are known about mastitis, it is abundantly clear that its control is enhanced by use of mechanically sound milking equipment and good milking practices. The National Mastitis Council has described a satisfactory milking system as one which (1) maintains a stable vacuum in the teat cup and at a level adequate for completely milking most udders in 3 to 5 minutes, (2) does not stress the tissues of the teat by excessive stretching and ballooning, (3) produces massage without harsh action, and (4) is designed so that the entire system can be sanitized efficiently and satisfactorily.

The Council considers proper milking procedure to include the following: (1) before the milking unit is applied to the udder, the operator takes 30 seconds to prepare the cow in the recommended manner to obtain milk letdown, and the milking machine should be applied immediately thereafter, (2) the teat cups are attached in a manner to limit the volume of air drawn into the system, (3) the teat cups are positioned as low on the teats as practicable, (4) the operator stays near the machine and, at the end point of milk removal, the claw is briefly pulled down to open the teat cavity and remove the strippings. Stripping by machine should not extend over a period of more than 15 to 20 seconds. Prolonging stripping can be

injurious to the udder, (5) before removing the machine, the vacuum to the teat cups is broken and the cups removed in a gentle manner, (6) to avoid over-milking, the operator should limit the number of machines in use. Two bucket type units, two movable pipeline units, or three fixed units, in a walkthrough barn usually represent maximum workloads with conventional milking systems.

Hooded, or small-mouthed pails may be used for carrying only that milk which has been drawn into them by hand-milking. Their extended use as carrying pails is considered hazardous in view of their inability to be covered or otherwise protected from flies, dust, splash, etc.

Insect and Rodent Control

The complete elimination of flies from the farm premises is practically unattainable. However, a major reduction of fly infestation is obtainable by the dairy farm operator who conscientiously follows a sustained program of sanitation, screening, and the proper use of insecticides.

The milk producer or plant operator must be continually aware of the potential hazard to men and animals which is inherent in most pesticides. It is important that he employ only those pesticides which are recommended by competent authority for the insect and rodent problems he seeks to overcome, and that he follow implicitly the manufacturer's directions for their use. Questions on the use of pesticides should be referred to the supervising health authority and/or county agricultural agent. U.S. Department of Agriculture Publication Nos. 270 and 283, and Agriculture Handbook No. 120 of the Agricultural Research Service and Federal Extension Service, also provide additional information on this subject.

Effective rodent control, like insect control, is dependent on sanitation for much of its success. The careful elimination of trash and woodpiles; the rodent proofing of feed bins, corn cribs, and similar structures; the prompt removal of spilled feed and manure to places of ultimate disposition; and the deliberate elimination of protected harborage areas in farm buildings, all tend to discourage rodents near the dairy farm. Such a program also pays excellent dividends in feed savings, lowered maintenance costs for farm buildings, reduced fire hazards, and lessened risk of disease outbreaks among farm animals.

In recent years, anticoagulant poisons (Warfarin - Fumarin, etc.) have offered improved means of controlling rodents on the farm. Used according to directions - and with due precaution against their consumption by domestic animals - these chemicals help keep the rodent population in check while additional preventive programs are instituted.

The Communicable Disease Center, Public Health Service, Atlanta, Ga., annual publication, Public Health Pesticides, provides an excellent resume of practices recommended for the control of insects and rodents.

Farm Bulk Milk Hauling

The unique position occupied by the farm bulk milk hauler makes him a critical factor in the current structure of milk marketing. As a weigher and sampler, he stands as the official - and frequently the only - judge of milk volumes bought and sold. As a milk receiver, his operating habits directly affect the quality of milk committed to his care. When his obligations include the collection and delivery of samples for laboratory analysis, he becomes a vital part of the quality control and regulatory programs affecting his producer patrons.

In implementing Section 3 of the Pasteurized Milk Ordinance, it is recommended that the health authority consider the establishment of criteria for the issuing of permits to farm bulk milk haulers. These criteria should embrace at least the following:

Training

Training frequently takes the form of classroom sessions in which the sanitarian describes pickup practices, demonstrates sampling and care of samples, and affords the candidate the opportunity for guided practice in these techniques. Basic considerations of sanitation and personal cleanliness, which are important to the protection of milk quality, are discussed here. Officials administering weights and measures frequently participate in these programs

and provide instruction in weighing of milk and the keeping of required records. An examination is usually administered at the conclusion of this program; candidates failing the test are denied permits until indicated deficiencies are corrected.

Regularly scheduled refresher short courses for farm bulk haulers by sanitarians and officials administering weights and measures would assist in maintaining and increasing the efficiency of the hauler.

Qualifications

1. Experience. —Experience which may include a required period of observation apprenticeship in which the candidate accompanies a permittee in the performance of his duties.

2. Personal References. —Permit applications should be supported by suitable references testifying to the character and integrity of the candidate.

Evaluation of Hauler and Operations

The periodic evaluation of hauling operations provides the health authority with an opportunity to check both the condition of the hauler's equipment and the degree to which he is observing required pickup practices.

The hauler's pickup technique is best checked when the sanitarian is able to accompany him on his route for at least a full day's run. When this is impossible, the sanitarian may arrange to intercept him at one or more farms.

The sanitarian's inspection will provide useful information on the overall attitude of the farm bulk milk hauler to his work. He should see the inherent danger in any evidence of carelessness on the job and should seek its correction. Frequent visits by the sanitarian are recommended in such instances.

Specific items to be evaluated in judging hauler performance should include:

1. Personal Appearance. —Haulers should be neat appearing, wear clean outer garments, and have clean hands.

2. Care of Equipment.—Milk hose, dippers, outlet valves, etc., should be protected from contamination. Dippers should be sanitized before use. Sampling tubes and similar devices, when delivered in a sterile condition, must be so maintained until used. Milk hoses should remain capped except when connected to bulk cooling/holding tanks and should be rinsed free of exterior soil as often as needed. Bulk cooling/holding tank outlets should be free of accumulations of milk when the delivery hose is attached. The routine cleaning and sanitizing of the bulk tank outlet is the responsibility of the producer; however, when necessary, the hauler should clean and sanitize the bulk tank outlet prior to attaching the delivery hose.

3. Protection of Milk.—Tank lids should be kept closed. Ports should be used for sampling and measuring, and checking the odor and appearance of the milk.

Delivery hose should be disconnected and capped before rinsing the bulk cooling/holding tank. The manhole cover of the bulk transport tank should not be opened during pickup or transport of milk to the milk plant, receiving station, or transfer station.

4. Protection of Samples. —The procedures for sampling and the care of samples shall be in substantial compliance with Standard Methods for the Examination of Dairy Products, of the American Public Health Association. Samples and sample containers must not be contaminated by improper handling during or after sampling. Samples must be properly identified and refrigerated as soon as drawn.

Certification of Industry Dairy Farm Inspectors

Purpose of Certification

The purpose of certification is to have the applicant formally demonstrate his ability to apply proper interpretations of the Pasteurized Milk Ordinance when inspecting dairy farms.

Designation of Individuals to be Certified

Candidates shall submit requests for certification to the health authority. The applicant for certification shall have had appropriate experience in the field of milk sanitation, and shall be a full-time employee of a milk plant, a producer association of officially designated laboratory, or shall be employed on a consulting basis in dairy field work by such establishments.

Recording of Qualification Data

Prior to conducting the certification procedure, background information shall be secured on the applicant. This shall include academic training, experience in milk sanitation and related fields, in-service courses attended, etc. This information is to be retained by the health authority as part of the applicant's file, along with appropriate records of his performance during certification examinations.

Field Procedure

Only one applicant shall be certified at a time. The certification is to be conducted without prompting from the health authority or comparison of inspection results in any way until the entire procedure is completed. Certification shall not be made during the course of an official inspection by the health authority.

At least 25 randomly selected dairy farms shall be visited. After the necessary inspections have been completed, the health authority shall compare his results with those of the candidate. The percentage agreement for each item of sanitation shall be determined by dividing the number of agreements by the total number of dairyfarms that were inspected.

Criteria for Certification

In order to be certified, an industry inspector shall agree with the health authority 80 percent of the time on individual items of sanitation, and shall further agree to comply with the administrative procedures established by the health authority for the program of dairy farm supervision. The health authority should allow sufficient time to discuss his findings with the applicant.

Duration of Certification

Certification of industry inspection personnel shall be for a period not exceeding 1 year from the date of formal certification or recertification unless revoked.

Recertification

The health authority shall notify the certified industry inspector of the need for renewal of his certification at least 60 days prior to its expiration; if recertification be desired, he will make appropriate arrangements for the renewal procedure. Recertification can be made for the succeeding 1-year period, by following the procedures outlined above.

Reports and Records

Upon satisfactory completion of certification or recertification, the certified industry inspector shall be issued a certificate. The milk plant(s) or officially designated laboratory(ies) employing the inspector shall be formally notified by letter of the certification; the letter shall outline the purpose of the certification and the conditions under which the certification may be retained. A copy of the notification letter, together with a copy of the qualification data above, and a resume of the percentage agreement on individual items shall be retained by the health authority.

Revocation of Certification

The certification of an industry inspector may be revoked by the health authority upon a finding that he is: (1) not in agreement with the health authority at least 80 percent of the time on items of sanitation in a field examination conducted as described in the Field Procedure outlined above; (2) not complying with the established administrative procedures of the health authority for the program; or (3) failing to carry out the provisions of the Pasteurized Milk Ordinance in the course of his work.

Certified Milk. The U.S. Public Health Service Milk Ordinance does not set standards for certified milk, but does recommend that it be pasteurized. The following standards for certified milk are set by the American Association of Medical Milk Commissions, Inc. This grade of milk is produced in accordance with the methods and standards adopted by the American Association of Medical Milk Commissions, Inc., under the supervision of local Medical Milk Commissions. Certified milk is labeled with the copyrighted seal of the above association.

Certified milk must be pure, clean, fresh, wholesome milk in its natural state, not having been heated and without the addition of coloring matter, or preservatives, nothing having been added and nothing taken away. Unless otherwise labeled, it is cows milk. It must be the product of healthy animals and produced and handled strictly in conformity with the above mentioned methods and standards and must be free from bacteria or other infectious agents pathogenic for man when taken orally. It must be free from objectionable odor and flavor.

Certified milk must contain not more than 10,000 bacteria per c.c. as determined by the examination of original bottles at the time it is delivered to the consumer. Certified milk to be pasteurized must contain not more than 10,000 bacteria per c.c. before pasteurization in samples taken at the pasteurization plant and not more than 500 bacteria per c.c. after pasteurization and as determined by the examination of original bottles at the time of delivery to the consumer. If counts exceeding these standards be found, daily counts are made and it counts below these standards be not restored within 10 days and maintained, certification may be suspended.

Certified milk must contain fewer than 10 organisms of the coliform group, and pasteurized grade must contain fewer than 1 coliform per c.c.

An average bacterial count for certified milk means the average weekly count. The weekly count means the average of all counts during the week.

The specific gravity of Certified Milk must be not less than 1.029 and contain no less than 12% total solids at 60°F. The average butterfat must be 4.0%, and the minimum for individual samples 3.5% unless otherwise indicated on the label. The average butterfat is based upon not fewer than 10 samples over a period of not less than 60 days or more than 90 days.

Special Certified Milks are allowed to be produced. They are:

1) Vitamin D Certified Milk should have a vitamin D potency of not less than 400 U.S.P. units per quart.

2) Soft-Curd* Certified Milk should show a curd tension below 30 grams by the Hill or equivalent method.

3) Certified Milk-Homogenized

4) Certified Milk -Modified is produced according to the prescription of a physician for individual feeding and labeled or tagged with physicians and consumers' name.

5) Processed or altered Certified Milk or its products made for market consumption, for example, flavored, or acidophilus milk, ice cream, butter, cheese, etc., must not be labeled "Certified" but may be labeled "Made from Certified Milk."

The sanitary provisions in producing and distributing Certified Milk are strict and satisfactory.

*Soft-curd milk. This product is more digestible and may be required by physicians for infant feeding. It may be produced by developing herds which naturally produce soft curds, by heating milk to as high as boiling, and by homogenization under pressures of 2,500 to 3,000 pounds. Enzyme and base-exchange methods are usually not accepted by health authorities because they necessitate "tampering" with the milk.

Cream and Its Preparation

The desirable features of table or coffee cream are: 20 to 25% fat content, low bacterial count, no "oiling off" in hot coffee, no "feathering" in hot coffee, no cream-plug formation, minimum amount of serum or skim milk in bottom of bottle, no visible sediment, pleasing flavor, no developed acidity, maximum ability to color coffee, maximum viscosity for a given fat percentage, attractive package. (See definition of coffee cream in U. S. P. H. S. Milk Code.)

The desirable features of whipping cream are the same as those for table cream except that the fat content should be 34 to 40%, it should whip quickly to form a stable foam, no attention need be given to "oiling off" or "feathering" in hot coffee. (See definition of whipping cream in U. S. P. H. S. Code.)

Separation. The milk should be preheated before separation in double-tube or plate heaters and separated at 90 to 95° F. Sediment is eliminated by a clarifier. Cream should be cooled as it leaves the separator.

Pasteurization. Cream is usually more aged than milk and kept longer by the consumer, therefore, a newer pasteurization temperature is employed, i. e., 145° F. for 30 minutes with as little agitation as possible, then flash-cool to 40° F. or lower.

Standardization. It is preferable to pasteurize before standardization. It is preferable also to use whole milk than skim milk for standardization, and the milk should be as old as the cream. If homogenization of the table cream be not practiced, the milk used for standardization should be pasteurized at a high temperature to prevent a skim milk layer from forming at bottom of bottle.

Aging - Whipping cream is usually aged at 35 to 40° F. for 24 hours before being sold in order to increase the stability of the shipped foam. This is unnecessary for table cream.

Delivery - Cream must be kept cold during delivery and thereafter to prevent decrease in viscosity, cream plug formation, and in case of table cream, the tendency to "oil off" in coffee.

Homogenization. This is not practiced for whipping cream since it decreases the ability to whip. The common reasons for homogenizing table cream is to reduce the formation of a skim milk layer, to increase the ability to color coffee, to reduce the tendency to "oil off" or to form a cream plug, and to increase the viscosity. Homogenized cream may tend to feather or curdle in hot coffee. This tendency is reduced by a two-stage process, i. e., first under 1000 pounds per square inch, and secondly under 500 pounds pressure.

Discussion of Defects in Creams.

1) Feathering is the coagulation of the cream on top of a cup of hot coffee. This is favored by calcium and magnesium salts, high acidity, and homogenization. Coffee or hard water may be the source of calcium and magnesium salts. Some coffee brew may have a high acidity. Sodium citrate inhibits fat clumping and reduces feathering but its use is not usually legal.

2) Skim milk layer in bottled cream is caused by the rising of the fat globules. This can be minimized by:

a) Increasing the fat percentage to 25% or more. It must be sold fresh and not held longer than 24 hours.
b) If standardization be necessary, the standardizing material (preferably whole milk) should be pasteurized at a high temperature.
c) Homogenization.

3) "Oiling Off" in hot coffee refers to the formation of oil droplets on the surface due to the destabilization of the fat emulsion caused by:

a) Partial freezing before separation.
b) Separation temperatures above 90° F.
c) Excessive mechanical agitation before separation.
d) Separation of cream testing 45% or more.
e) Holding cream warm for several hours before pasteurization.
f) Prolonged holding at the pasteurization temperature before cooling.
g) Coil vats.
h) Heating higher than 145° F.
i) Pumping of cream from pasteurizer to cooler with a pump of too large capacity.
j) Cooling cream in vat.
k) Permitting cream to remain at room temperature for several hours before using.

This condition can be minimized by:

a) Homogenization, or
b) avoiding unnecessary agitation, heating rapidly and flash-cooling, and holding at 145° F. at 30 minutes with slow agitation.

4) Inability of cream to color coffee. This is due to inadequate number of suspended particles (fat, casein, and calcium phosphate) large enough to reflect light to produce a whitening effect. This inability to overcome by:

a) Increasing fat content.
b) Increasing the solids-not-fat content.
c) Homogenization.

5) Lack of viscosity may be due to:

a) Decreased fat percentage for table cream below 25% and for whipping cream below 34% to 40%.
b) Amount of fat clumping.
c) Size of the fat globules. The larger the globules the greater the viscosity.
d) Temperature: Viscosity decreases as temperature increases.

6) Methods of Controlling cream viscosity.

a) Increasing fat content.

b) Cream should be separated at 90°F., cooled, and then pasteurized at 145°F.

c) Slow agitation at cool temperatures, however, flash-cooling is more satisfactory.

d) Holding cream at 35 to 40°F. gives greatest viscosity at end of 24 hours. Holding longer causes separation of fat from milk.

Other Products of Milk

There is a danger of not carrying over the strict sanitary measures practiced in milk production and distribution to the realm of the milk products industry. This hazardous tendency must be continually watched by sanitarians since all the pathogenic organisms that may be carried in fresh milk will survive in milk products. It is therefore of fundamental importance that milk products be manufactured from good quality whole milk that has been properly pasteurized.

Casein - is that solid or semi-solid material obtained from skimmed milk or buttermilk by precipitation of the milk solids by the addition of acids or whey. The casein may be subsequently washed, ground and dried.

Whey - is the liquid or semi-liquid material remaining after the removal of fat and casein from milk or cream in the process of cheese making.

Sweetened Condensed Milk, Sweetened Evaporated Milk or Sweetened Concentrated Milk - is the food product obtained by the evaporation of a considerable portion of the water from whole, fresh, clean milk, to which sugar (sucrose) has been added. It contains, all tolerances being allowed for, not less than twenty-eight (28%) percent of total milk solids, and not less than eight (8%) percent of milk fat.

Condensed Milk, Evaporated Milk or Concentrated Milk - is the food product obtained by the evaporation of a considerable portion of the water from whole, fresh, clean milk, and contains, all tolerances being allowed for, not less than twenty-five and five-tenths (25. 5%) percent of total milk solids and not less than seven and nine-tenths (7. 9%) percent of milk fat.

Condensed Skimmed Milk, Evaporated Skimmed Milk, Concentrated Skimmed Milk - is the food product obtained by the evaporation of a considerable portion of the water from fresh, clean, skimmed milk, and contains, all tolerances being allowed for, not less than twenty (20%) percent of total milk solids.

Sweetened Condensed Skimmed Milk, Sweetened Evaporated Skimmed Milk, Sweetened Concentrated Skimmed Milk - is the food product obtained by the evaporation of a considerable portion of the water from fresh clean skimmed milk to which sugar (sucrose) has been added. It contains, all tolerances being allowed for, not less than twenty-eight (28%) percent of total milk solids.

Dried Whole Milk or Powdered Whole Milk - is the food product obtained by the removal of water from whole, fresh, clean milk. It contains not less than twenty-six (26%) percent of milk fat, and not more than five (5%) percent of moisture.

Dried Skimmed Milk or Powdered Skimmed Milk - is the food product obtained by the removal of water from fresh, clean skimmed milk. It contains not more than five (5%) percent of moisture.

Filled Milk or Imitation Milk - means any milk or milk products or any combination of milk, cream, or skimmed milk products in which some fat or oil, other than milk fat, has been substituted for the natural butterfat of the milk, thus producing a product which resembles milk or milk products, provided, that this definition shall not include any distinctive proprietary food compound not readily mistaken for milk or cream or for condensed, evaporated, concentrated, powdered, dried or desiccated milk or cream.

Butter is the clean, sound, food product made by gathering, in any manner, the fat of fresh or ripened (partially sour) milk, or cream, into a mass which also includes a small portion of other constituents natural to milk, with or without common salt, with or without additional harmless food coloring. This product should contain not less than 80% milk-fat according to federal regulation.

Renovated butter or processed butter is the product made by melting and reworking butter in order to improve the flavor or eliminate impurities. Milk or cream is usually used in this process. The use of such chemicals as sodium bicarbonate are prohibited in some places. Renovated butter should contain not more than 16% moisture.

Butter turns rancid because fat changes into fatty acids. Rancid butter may be renovated by washing with skim milk or with water containing sodium bicarbonate which neutralized the acids. Rancid odors and tastes may be blown out with steam. Enzyme action aiding decomposition of fat may be stopped by adding hydroquinone, and advancing decomposition may be checked with chlorine or other preservatives. Renovated butter must be so labeled. The above practices may be used only where they are legal.

Fresh unpasteurized butter contains millions of microorganisms per gram. Bacterial counts diminish with time (85% in 2 weeks - 93% in 4 weeks). It may contain any of the pathogenic germs found in milk. Tuberculosis germs may survive as long as 3 to 6 months after manufacture from original whole milk. Cold preserves rather than kills germs. Butter should be made from pasteurized cream and labeled pasteurized butter.

Cheese is the product made from the separated curd obtained by coagulating the casein of milk, skimmed milk, or milk enriched with cream. The coagulation may be accomplished (1) by means of rennet or other suitable enzyme, (2) by lactic fermentation, or by a combination of the two. The curd may be modified by heat, pressure, ripening ferments, special molds, or suitable seasoning. Certain varieties of cheese are made from the milk of animals other than the cow. Sanitary regulations apply to all cheese made from the milk of any animal, but where milk of animals other than the cow is used, the cheese shall be so labeled unless it be a variety of cheese made only from the milk of a certain animal and that fact is known and accepted by the consuming public. Any cheese may contain added harmless food coloring. The name "Cheese" unqualified, means Cheddar Cheese (American Cheese, American Cheddar Cheese).

Cheddar Cheese, American Cheese, American Cheddar Cheese - is a cheese made by the Cheddar process from heated and pressed curd obtained by the action of rennet on milk. It contains not more than thirty-nine (39%) percent of water, and in the water-free substance, not less than fifty (50%) percent of milk fat. Cheddar Cheese obtains its name from a special cutting and handling process.

Cream cheese - is the unripened cheese made from whole milk enriched with cream. It contains, in the water-free substance, not less than sixty-five (65%) percent of milk fat. After the milk has coagulated the whole is dumped upon a rack to drain, and the curd frequently stirred to facilitate removal of the whey. Salt is added to taste.

Pasteurized Cheese - Pasteurized Blended Cheese - is the pasteurized cheese product made by comminuting and mixing, with the aid of heat and water, one or more lots of cheese into a homogeneous, plastic mass. The unqualified name "Pasteurized Cheese", "Pasteurized-blended Cheese" is understood to mean pasteurized Cheddar Cheese, pasteurized-blended Cheddar Cheese, and applies to a product which conforms to the standard of Cheddar Cheese. Pasteurized cheese, pasteurized-blended cheese, bearing a varietal name, is made from cheese of the variety indicated by the name and conforms to the limits for fat and moisture for cheese of that variety.

Cottage Cheese - See definition in U.S.P.H.S. Milk Ordinance.

Process Cheese - is the modified cheese made by comminuting and mixing one or more lots of cheese into a homogeneous plastic mass, with the aid of heat, with or without the addition of water, and with the incorporation of not more than three (3%) percent of a suitable emulsifying agent. The name "process cheese" unqualffied, is understood to mean Cheddar Cheese, and applies to a product which contains not more than forty (40%) percent of water, and, in the water-free substance not less than fifty (50%) percent of milk fat. Process cheese, qualified by a varietal name is made from cheese of the variety indicated by the name and conforms to the limits for fat and moisture for cheese of that variety.

Skimmed Milk Cheese - is cheese made from skimmed milk and the finished product contains

less than fifty (50%) percent of butterfat based on the moisture free substance or contains more than thirty-nine (39%) percent moisture.

Special Cheeses - There are a number of varietal cheeses on the market with the names fixed by trade custom, by special processes of manufacture, or by location of manufacture. The use of such names on cheese, unless processed or manufactured according to special trade custom, process of manufacture, or location of manufacture, is prohibited. The following definitions apply to the Special Cheeses:

Stilton Cheese - is cheese made by the Stilton process from unpressed curd obtained by the action of rennet on whole milk with or without added cream, and which otherwise conforms to the definition of cheese. During the ripening process a special blue-green mold develops, and the cheese thus acquires a marbled or mottled appearance in section.

Neufchatel Cheese - is cheese made by the Neufchatel process from unheated curd obtained by the combined action of lactic fermentation and rennet on whole milk. The curd, drained by gravity and light pressure, is kneaded or worked into a butterlike consistency and pressed into forms for immediate consumption or for ripening; and which otherwise conforms to the definition of cheese. The finished cheese contains, in the water-free substance, not less than fifty (50%) percent of milk fat.

Roquefort Cheese - is cheese made by the Roquefort process from unheated, unpressed curd obtained by the action of rennet on the whole milk of sheep, with or without the addition of a small proportion of the milk of goats, and which otherwise conforms to the definition of cheese. The curd is inoculated with a special mold (Penicillium roqueforti) and ripens with the growth of the mold. The fully ripened cheese is friable and has a mottled or marbled appearance in section.

Gorgonzola Cheese - is cheese made by the Gorgonzola process from curd obtained by the action of rennet on whole milk and which otherwise conforms to the definition of cheese. The cheese is ripened in a cool, moist atmosphere conducive to the development of an inoculated blue-green mold and thus acquires a mottled or marbled appearance in section.

Edam Cheese - is a cheese made by the Edam process from heated and pressed curd obtained by the action of rennet on whole milk or on partly skimmed milk and which otherwise conforms to the definition of cheese. It is commonly made in spherical form and coated with a suitable oil and harmless red food coloring.

Swiss Cheese - is cheese made by the Ementhaler process from heated and pressed curd obtained by the action of rennet on whole milk or on partly skimmed milk. It is inoculated with special gas-producing bacteria which, as the cheese ripens, causes the formation of "eyes" or holes. The finished cheese contains, in the water-free substance, not less than forty-five (45%) percent of milk fat, and which otherwise conforms to the definition of cheese.

Camembert Cheese - is cheese made by the Camembert process from unheated, unpressed curd obtained by the action of rennet on whole milk or on a slightly skimmed milk. As it ripens, a growth of special mold (Penicillium camemberti) develops on the outer surface. The finished cheese contains, in the water-free substance, not less than forty-five (45%) percent of milk fat, and which otherwise conforms to the definition of cheese.

Limburger Cheese - is cheese made by the Limburger process from unpressed curd obtained by the action of rennet on whole milk. The curd is ripened in a damp atmosphere by a special fermentation process. The finished cheese contains, in the water-free substance, not less than fifty (50%) percent of milk fat and which otherwise conforms to the definition of cheese.

Technique for Collection and Shipment of Specimens for Laboratory Examination

Material:

For Retail Samples - Cooling box; tight-fitting waterproof covering for bottles.

For Wholesale Samples - Cooling box; metal or glass tubes; metal tubes should be about 61 cm. (24in.) long, 0.8 cm. outside diameter, 0.1 cm. wall thickness, and preferably of aluminum; sample bottles sizes 0.5 to 1.0 oz. or optional sizes 2.0 to 8.0 oz; dippers if sampling tubes

be not used; stirring rod; hypochlorite; cold running water or steam; rinsing containers and sterilizing container.

Each Health Department should own one or several milk and water containers, depending on local needs, for shipment of samples to the laboratory. Each container should have the name and address of the health unit printed on the outside so that the laboratory may immediately return same to correct owner.

Milk and Cream

A. Technique, Instructions, and Precautions for Collection

1) Retail Samples. Procure sample in its original container. The container should remain unopened until it reaches the laboratory. Protect caps and lips of sample container at all times from contamination with tight-fitting, waterproof coverings—especially when bottles of milk or cream are shipped to laboratory. Procure not less than 1 pint if sediment test is to be made.

2) Wholesale Samples. Transfer not less than 10 millileters (10cc) of the well mixed milk or cream from the previously unopened container, preferably with a suitable sterile metal or glass tube, to a sterile sample container allowing the complete contents of the tube to drain into the latter. The sample container should be a clean screw-cap vial, glass-stoppered bottle, or other leakproof bottle. For convenience of packing for shipment, use preferably sample bottle sizes 0.5 to 1.0 oz. or optional sizes 2.0 to 8.0. Before taking sample, agitate the milk or cream vigorously with a sterile stirrer long enough to reach the bottom of the container. Satisfactory facilities for stirring cans of milk or cream consist in providing one can connected with a continuous flowing source of clean cold water and another can containing a hypochlorite solution (maintained at not less than 100 parts per million of available chlorine) for practical sterilization of the stirrer. Rinse stirrer first in cold water and then allow it to stand in the hot water or chlorine solution while making preparations to take the next sample. Do not use the metal or glass sampling tube as an agitator unless no other stirring instrument be available. If sampling tube be used for stirring, remove it completely from the liquid before taking the sample, then insert it, not too rapidly, to the bottom of the container with the top of the tube open. Place the finger securely over the open end, withdraw the tube and its contents and aseptically transfer the entire liquid contents to a sterile sample bottle or vial. Remove each sample with separate sterile sampling instrument and reserve the entire contents for the sample. Avoid filling the container more than two-thirds full. Wash and sterilize each tube and sample container before re-use.

The temperature of the samples may be determined by:

1) Inserting the thermometer in an adjacent bottle of milk in the case which has been handled identically as the samples to be examined.

2) Inserting thermometer in sample after removal of portion to be examined.

3) Inserting thermometer in any sample which will no longer be used for bacteriological examination.

3) Other Samples. Samples collected from the breast, or from individual quarters of the udder, or if collected at different stages of the pasteurization process are handled in the same sterile manner as above described. If carried directly to laboratory the samples may be collected in test tubes which are tightly closed with sterile rubber or cork stoppers. Do not use cotton plugs to close sample containers.

4) Chemical Analysis. Samples for chemical analysis need not be collected aseptically, but at least 1 pint, and preferably 1 quart of sample should be obtained and samples must arrive in laboratory in an unsoured otherwise undecomposed condition. No preservatives should be added to samples.

B. Labeling and Sealing of Sample.

Sample must be collected directly from the individual, firm, or agent thereof upon whom rests the responsibility for the nature of its contents. The information slip must be accurately and legibly filled out with the date, name of firm or dairy farm, name of owner, mailing address and location of farm, plant, or other establishment, and signature of inspector. All suspicions about the sample must be noted on the information slip.

1) Larger Containers. The top of the bottle is covered with two or more layers of wax paper. The size of wax paper should not be smaller than 6 inches by 12 inches so that when it is folded it makes at least two layers 6 inches by 6 inches, between which the folded information slip is placed. The top of the bottle is covered with wax paper so that the information slip rests over the cap. The wax paper is drawn down and tightly sealed around the neck of the bottle with scotch tape.

2) Smaller Bottles. If bottles be too small to be labeled and sealed as described above the bottles are tagged and sealed and the information slips are placed in a water-tight tube or bottle and shipped with sample. It is most important that the tags on the bottles and the corresponding information slips be identified.

C. Care of Specimen Prior to Shipment.

Cool all samples as promptly as possible to a temperature below 50°F., and hold within this temperature range until analyzed. The results of the analysis of any sample, the temperature of which exceeds 45°F. during a storage period of 4 hours may be unreliable. Use trays or other suitable receptacles provided with compartments or baffles to hold the sample containers in a vertical position.

D. Preparation for Shipment.

When shipping and transporting samples to the laboratory, use large well constructed boxes which will permit the use of sufficient refrigerant to maintain the desired temperatures until containers arrive at their destination. Best way to get samples to laboratory is to transport them personally by automobile. In such case, when liquid refrigerant is in direct contact with sample, do not allow it to raise above the shoulder of the bottle, and always keep the bottle in a vertical position. When milk bottles are to be shipped in water containing cracked ice, protect the entire top of the bottles securely with waterproof paper or metal foil. When screw-cap vials or glass-stoppered bottles are used, place them in one-tier-deep metal watertight containers for further protection during transportation. Cover these watertight containers completely with cracked ice in well constructed wood, metal-lined wood, or metal boxes. A recommended procedure is to pack samples in 20 to 30 times their volume of an intimate mixture of crushed ice and saw-dust wood shavings, or excelsior, including large pieces of ice about double the size of a closed fist. The external container should be of adequate size to hold the samples and refrigerating medium and strong enough to stand handling during shipment. If this procedure be used, holes must be placed in the bottom of the container to allow drainage of the melted ice. To insure proper handling during transportation, attach handles to cases to encourage shipment in an upright position and label cases conspicuously "THIS SIDE UP" on the appropriate surface. Also mark container: PERISHABLE - NO DELAY, RUSH.

All milk samples for routine examination should be sent directly to the laboratories.

E. Special Precautions.

1) Do not take official samples from containers of unstirred milk or cream, or from the stream as the unstirred liquid is poured from the can.

2) Do not take official samples from the mixed milk of several cans after the milk has been dumpted into the weigh-vat.

3) Any sample, the temperature of which has been taken by inserting a thermometer, can no longer be used for bacteriological examination.

4) Prevent samples from freezing when dry ice is used as a refrigerant.

5) For taking samples, always use sampling tubes, never dippers, where there is any question about the thorough agitation of milk or cream.

6) Telegraph the laboratory as to the approximate time of arrival of samples.

7) It is very important for provision to be made for draining melted ice from the bottom of shipping containers.

Ice Cream and Other Frozen Desserts.

A. General Instructions and Precautions.

To sample bulk frozen ice cream from the container or can, remove about 1 2 to 1 inch of the upper surface and take the sample from the freshly uncovered lower layer. Place samples in air-tight containers sueh as friction top paper ice cream containers or fruit jars. Dixie cups, sticks,

bricks, and slices should be delivered frozen to the laboratory, particularly if coated.

Samples shipped for long distances should be shipped frozen with sufficient dry ice in an insulated container to maintain the sample in a frozen condition until received by the laboratory.

B. Sealing, Labeling and Identification
This is the same as recommended for milk and cream.

Cleaning and Bactericidal Treatment: Utensils, Containers, and Equipment.
By approved bactericidal process is meant the application of any method or substance for the destruction of pathogens, and of other organisms as is practicable, which is effective and which does not adversely affect the equipment, the milk or milk products, or the health of the consumers.

The bactericidal procedures by steam, hot water, or hot air as outlined below are designed to destroy vegetative bacteria, but not necessarily spores. Spore-forming bacteria may impart undesirable flavors to the milk, or may have undesirable effects. If it should be desirable to destroy all spores, more severe treatment is necessary, such as exposure to hypochlorites for extended periods.

Steam, hot-water, or hot-air treatment is not to be accepted as fulfilling satisfactory compliance, unless the equipment or containers be completely immersed or exposed for the required time, or longer, at the required temperature, or higher, throughout the period of exposure. Pouring hot or so-called boiling water from vessel to vessel is not adequate, and is not to be accepted.

All multi-use containers should be thoroughly cleaned after each use, all equipment thoroughly cleaned once each day, and demounted equipment washed and stored in a clean place, off the floor. Surfaces that appear rough or greasy to sight or touch must be considered not clean. All demountable equipment, except that which is effectively cleaned in place, must be taken down once each day for cleaning, including thermometer fittings where pressure-tight seats are not employed. As a supplement to routine cleaning with alkaline detergents, the alternate use of acid cleaners should be employed as frequently as necessary to insure thorough cleaning.

All containers should be given bactericidal treatment after each cleaning; and all equipment is given bactericidal treatment at least once each day, especially just before the beginning of the day's operations, employing one or a combination of the methods prescribed below.

Any completely enclosed equipment which is continuous with the pipe system, and under pressure from the pipe system, such as preheaters, pumps, filters, valves, tubular holders, regenerator heater-coolers, clarifiers, homogenizers, etc., must be considered as having been adequately treated with steam, hot water, or chemicals when proper temperatures or approved chemical solutions of proper strength are employed.

Covers and other closures, unions (except on cleaner-in-place lines), filler valves, and similar parts should be slightly loosened to insure that all surfaces will be thoroughly treated, and to minimize expansion and contraction cracks or strains.

When steam or hot water is used, coolers should be drained of refrigerant, or the refrigerant intake valve should be closed and the return valve opened to provide for the expansion of the refrigerant.

Equipment not under pressure from the pipeline, or of which the entire surface is not reached, such as weigh vats, storage vats, forewarmers, clarifiers, separators, pasteurization vats and pockets, coolers and cooler covers, bottlers, capper heads, etc., either must be treated separtely, or the parts not reached must be given supplementary treatment.

Bactericidal Treatment of Entire Assembled Equipment Immediately Prior to Day's run - Bactericidal treatment is required of the entire assembled equipment immediately prior to the day's run. This may be done by means of steam, hot water, or chemical solution, as follows:

(a) When steam is used, each group of assembled piping is to be treated separately by inserting the steam hose into the inlet and maintaining steam flow from the outlet for at least 5

minutes after the temperature of the drainage at the outlet has reached 200°F. (The period of exposure required here is longer than that required for individual cans, etc., because of the heat lost through the large surface exposed to the air.) Covers must be in place during treatment.

(b) Hot water may be used by pumping it through the entire equipment. The temperature of the water at both the inlet and the outlet end of the assembly must be at least 170°F. for at least 5 minutes. When the assembly is so long that it is difficult to obtain this temperature and time at the outlet end, the equipment should be treated in sections, or steam must be introduced at various points in the system in order to boost the temperature.

(c) When chlorine or another chemical solution is used, the solution appearing at the outlet end must show the required strength. The chemical solution must be pumped through the entire equipment for at least two minutes. Unions and other connectors should be slightly loosened to permit treatment of gaskets and threads, except on lines cleaned-in-place.

Here again, such surfaces as are not reached by the chemical solution must be treated with steam as previously described, or the spray method of applying chemical solution must be used for such surfaces as are not reached by the flowing solution. Header ends and connecting piping of cabinet coolers should not be overlooked, as condensation from them may enter the collecting trough.

Cleaned-in-Place Milk Lines - Cleaning of in-place pipelines is dependent upon circulating appropriate cleaning solutions at relatively high velocities. The average velocity of not less than 5 feet per second has proved satisfactory. The milk-pipe lines should slope up from the pump to the outlet, without any dips, to provide (1) for self-drainage of the solutions, and (2) for maintenance of full lines during circulation, to insure contact of solutions with all milk-contact surfaces. A separate pump of adequate capacity should be provided to maintain full lines for the particular circuit. Valves in the line, except at the outlet, should be fully open, to prevent decrease in velocity during circulation of cleaning and bactericidal solutions.

The circulating system should consist of one or more solution tanks connected to the suction side of a pump large enough to circulate solutions at the desired velocity; and the circulating system should be so designed and operated as to maintain full lines throughout the circulating period. The sanitarian should require that a recording thermometer of proper range be connected in the return line near its downstream end to maintain a record of the temperature and time when the line is exposed to cleaning and bactericidal solutions, and the thermometer charts must be dated and kept on file for three months.

A suggested procedure for cleaning in-place milk lines is as follows:

Immediately after concluding the day's operations, all connections between cleaned-in-place lines and processing equipment should be removed, and the lines rinsed thoroughly with water at 100° to 120°F., the rinse water being continuously discarded. Each day, an alkaline non-depositing cleaning solution, heated to 120°F. or above, should be circulated for at least 15 minutes before discharging. If water conditions are such that deposits form at these temperatures, the water may be softened, or cleaning solutions at 115° to 120°F. may be used for longer periods. If necessary for hot-milk lines, an acid cleaning solution, heated to 120°F. or above, should be circulated at least 15 minutes before discharging. These are suggested temperature ranges, and the recommendations of the detergent manufacturers should be followed with respect to the temperature and the concentration of specific acid or alkaline solutions. To insure proper strength of solution and to avoid corrosion, the cleaning compound should be dissolved uniformly prior to circulation. The lines should be rinsed; all caps, plugs, and special fittings, including valve seats, crosses and tee ends, should be removed and brushed clean, and the lines examined and brushed if necessary. Used solutions should be discarded, the solution tank thoroughly cleaned each day, and fresh solutions prepared daily. The outside of the lines also should be cleaned.

After reassembling, and shortly before starting milk flow, the lines must be given bactericidal treatment by circulating for 10 minutes either water maintained at not less than 180°F., or a solution containing at least 200 ppm. of available chlorine, as hypochlorite, or some other equally effective bactericidal solution approved by the health department. Solutions must be drained before starting the flow of milk.

The sanitarian must check the velocity of solution flow at the time of installation, and after every change which affects the flow characteristics, by timing the filling of a can. (The maximum time required to fill a 10 gallon can, for a velocity of at least 5 feet per second, is 60 seconds for 1 inch pipe, 25 seconds for 1 1/2 inch, 14 seconds for 2 inch, 9 seconds for 2 1/2 inch, 6 seconds for 3 inch, and 3.5 seconds for 4 inch. As the actual diameters of glass pipe are slightly larger, the filling times will be approximately 10 percent less.) The filling time required should be based on the diameter of the largest pipe in the line.

The Sanitarian must check the recording-thermometer charts to note the time of exposure to solutions and their temperature. He must also check the efficiency of the cleaning and bactericidal-treatment procedures at least four times during each 6 month period, by swabbing or rinsing appropriate places in the installation for samples for bacteriological examination.

Other methods of cleaning and bactericidal treatment may be proved equally effective. Great advantages have resulted from the use of industrial glass piping in the food industry, particularly for milk. Glass has a smooth, hard surface which minimizes the possibility of foreign material lodging in or adhering to these surfaces; cleaning and sterilizing of pipe lines, therefore, present an entirely different problem than in the case of metals and other materials. Glass piping can be cleaned and sterilized without brushing or scouring the surfaces, by circulating detergents and sterilizing solutions through the lines. Time will tell whether this type of equipment will serve satisfactorily in milk plants.

The inner surface of the entire glass pipe line is available for visual inspection at all times. If milk-stone or any other deposit, which might impair the sterility of the line, begins to form on any of the glass surfaces, it is at once apparent so steps can be taken for its removal.

The following summarizes a method for cleaning and sterilizing milk lines which needs to be thoroughly experimented with to determine its sanitary adequacy.*

1) Immediately after the milk run is completed, flush the lines with cold water.

2) Insert a sponge 2 1/2 to 3 times the diameter of the line, in the inlet end, and then with the cold water pressure, force it through the entire line.

3) Flush line with water until the water runs clear.

4) Circulate cleaning solution. Various types of detergents may be used. One containing a wetting agent is recommended. This detergent is mixed in warm water in the detergent tank - usually 0.25 to 1% by weight. This cleaning solution is recirculated through the line by a pump for a period of 15 minutes to 1 hour. When this period is ended, a sponge is usually forced through the line by means of the cleaning solution to remove any deposit which still remains on glass surfaces.

5) After draining the line, all metal parts, such as valves, stainless steel connections, pumps, and other equipment are dismantled, scrubbed and reassembled in the line.

6) The pipe line is then sterilized by one of three methods - circulation of chlorine solution, at least 100 ppm; circulation of hot water at 180 - 190°F. for 5 minutes; bleed low pressure steam (15 pounds per square inch) through the line until the complete system has reached sterilizing temperature.

7) Allow the line to drain and then cap the ends until the next run of milk. Milk lines should be arranged so that a continuous circuit of pipe can be set up during the cleaning operation to permit recirculation of the detergents.

Bottler Treatment - The bottler must be completely assembled before being given bactericidal treatment. In the case of hot water or chemical treatment, the bottler must be in operation during the process so as to insure the bactericidal treatment of all valves and fittings.

In the case of steam treatment this is not necessary, but the valves must be individually treated in place. This operation can be made most effective by attaching to the end of the steam hose a device which will enclose the valve and confine the steam. The valves, valve rubbers, and drip deflectors may also be treated by immersing in chlorine solution containing 200 ppm. of available chlorine. This is done with the valves in place, by the use of a container large enough to permit immersion of all exposed parts.

*Heating and Ventilating, November 1950 - Industrial Glass Piping, Shand, E.B. p. 80-81.

Thermophilics-Thermodurics - Although thermophilic and thermoduric organisms are generally considered non-pathogenic, their presence in milk indicates a lack of sanitation. They are usually of raw-milk origin, but once milk equipment is contaminated with these organisms, more intensive bactericidal treatment, or a change in treatment methods is indicated. Hot water or steam at 200°F. for more than 10 minutes, or chlorine solution at 200 ppm. of available chlorine for two minutes or longer, may be necessary. Laboratory pasteurization of the supplies of individual producers, and the improvement of sanitary procedures at the dairy farm, are indicated when thermoduric organisms are present. Thermophilic bacteria are a problem of the pasteurization plant and may indicate a need for improvement in processing procedures, cleaning and bactericidal methods, or condition of equipment.

Bottle and Can Treatment - Small plants, for which the use of automatic washers may be deemed impracticable frequently wash their bottles manually, in which case a 2-compartment vat must be provided —one compartment for washing, the other for rinsing. For these plants, the use of the steam cabinet, an individual steam-jet plate provided with a hood, or chemical immersion-type apparatus may be accepted as compliance. When a chemical solution is used for treating bottles, there must be a rinse treatment between the washing and the chemical treatment which necessitates the provision of a 3-compartment vat. The bactericidal treatment must comply with all requirements.

Larger plants should use automatic bottle-washers. Such washers must provide for bactericidal treatment by means of steam, hot water, or approved chemical treatment. In a soaker-type bottle-washer, in which bactericidal treatment depends upon the causticity of the washing solution, the caustic strength for a given soaking time and temperature should be as specified in the following table. When caustic is so used, subsequent final rinsing of the bottles must be with water which is kept sterile by means of heat or an approved chemical bactericide, to prevent recontamination of the treated bottle during the rinsing operation. For determining the strength of the soaker solution, the A. B. C. B., (American Bottlers of Carbonated Beverages, Washington, D. C.) alkali test, the A. B. C. B. caustic test, or other suitable test may be used. The caustic strength must be tested monthly by the sanitarian. Acid solutions may be used in lieu of strong alkali solutions in soaker-type bottle-washers.

Table 45. Combinations of Causticity, Time and Temperature of Equal Bactericidal Value, for Soaker Tank of Soaker-type Bottle-washers (Based on A. B. C. B. specifications for Beverage Bottles)[1]

Time in Minutes	Temperature, °F.						
	170	160	150	140	130	120	110
	Concentration of NaOH, percent						
3	0.57	0.86	1.28	1.91	2.86	4.27	6.39
5	.43	.64	.96	1.43	2.16	3.22	4.80
7	.36	.53	.80	1.19	1.78	2.66	3.98

Sterility Tests - Bottles and cans must be tested by means of bacteriological rinse and swab examinations conducted at least four times during each 6 month period.

Steam and Hot Air

a) Steam Cabinets - Cabinets with auxiliary steam boilers should be provided with vents or valves at the bottom, to permit the discharge of cold air when steam is admitted, and with a drain for the escape of water of condensation.

A suggested procedure for steaming is as follows: Store all containers (in an inverted position) and other equipment in the cabinet, taking care that no article be less than 6 inches from the floor. Raise steam to full pressure in the boiler; then admit steam to the cabinet slowly. The steam

1. Dr. D. H. Jacobsen, The Milk Dealer, June 1947.

valve should not be opened wide, as this may carry over boiler water and boiler compounds which may contaminate utensils, as well as reduce boiler efficiency. Steam flow must be maintained long enough to keep the thermometer reading above 170°F. for at least 15 minutes, or above 200°F. for at least 5 minutes. Allow articles to cool in the cabinet.

In cabinets with steam generated in the bottom, sufficient water may first be heated for washing purposes, and drawn off. After being washed, all articles to be treated should be placed in the cabinet, the cabinet closed, and the remaining water kept at a boil for such a period as will keep the thermometer reading above 170°F. for at least 15 minutes, or above 200°F. for at least 5 minutes.

b) Hot-air Cabinets - Hot-air cabinets must be of sufficient capacity to accommodate the largest piece of equipment. Metal construction is preferred, and the design should provide a 1 inch air-space between the inner and outer walls. The floors should be provided with a slat platform, or other means to permit air circulation. A vent, equipped with a damper or a valve, should be provided at the top of the cabinet. Installation of a fan in the cabinet will minimize internal temperature differences. An indicating thermometer must be installed in the coldest zone. Traces of moisture in cans or utensils which are inverted during heating will increase the bactericidal efficiency of hot-air cabinets. However, cans must be thoroughly dried out during the heating process to prevent bacterial growth during subsequent storage.

All cans, pails, or other equipment should be stored in the cabinet in an inverted position, and so arranged as to permit air circulation. The 20 minute holding period should commence when the temperature in the cold zone reaches a minimum of 180°F., as indicated by the thermometer. After treatment, allow articles to cool in the cabinet.

c) Suggested Specifications for Indicating Thermometers for Steam and Hot-air Cabinets -
Type: Metal scale-case; mercury-actuated; regular angle or straight style.
Magnification of Mercury Column: To apparent width of not less than 1/16 inch.
Scale Range: 130°F. to 220°F., with extension on either side permitted.
Temperature Represented by Smallest Scale Division: Not more than 2°F.
Number of Degrees per Inch of Scale: Not more than 32.
Accuracy: Within 2°F., plus or minus, between 150°F. and 212°F.
Stem: Two inches long beyond face of flange, for single-thickness metal sterilizers; eight inches long, for walls not over six inches thick.
Stem Fitting: Iron or other metal flange.

d) Steam Jets - Steam jets are sometimes used when the articles to be treated are limited to pails, cans, and strainers. Jets, when properly constructed and operated, will bring the equipment to a considerably higher temperature than is generally true of steam cabinets, and for this reason a shorter exposure period, of at least one minute, is approved.

In using the steam jet, care must be taken that each article is kept over the jet for at least one minute. Before removing any article, it should be too hot to handle with bare hands. When cases of bottles are treated by a steam jet, the steam must emerge from a perforated plate as large as the case, so that it will be uniformly distributed; and the case must be covered with a tight hood which will confine the steam.

e) Immersion in hot water at a temperature of at least 170°F. for at least 2 minutes, or exposure to a flow of hot water at a temperature of at least 170°F. (at the outlet) for at least 5 minutes, as determined by use of a suitable thermometer.

Chemical Bactericides

a) General - An intermediate, plain water rinse must be provided between the wash and the bactericidal treatment of milk utensils and equipment, where chemical bactericides are used. Bactericidal action is increased by raising the temperature, or by increasing the concentration of the solution. Hydrogen-ion concentration (pH) also influences the bactericidal action tremendously. The recommendations given below are for solution temperatures of about 75°F. Additional exposure should be allowed for lower temperatures. For each 18°F. drop in temperature below

75°F., the exposure time should be approximately doubled.

Chemical treatment should not be accepted as satisfactory compliance unless the equipment and containers first have been thoroughly cleaned. Following cleaning, articles should be completely immersed or exposed (including spraying, where permitted) for at least two minutes (or longer, with some bactericides) in a solution of at least the minimum concentration recommended below, and within the limits of the prescribed pH.

All milk-contact surfaces must be wetted by the bactericidal solution, and piping so treated must be filled. Bactericidal sprays may be used for large equipment. Chemical solutions, once used, must not be re-used for other purposes.

b) Chlorine Bactericides: Hypochlorites - The use of these bactericides may be considered as satisfactory compliance. Either calcium or sodium hypochlorite (powder or solution) is satisfactory. Some hypochlorite products are more highly concentrated than others, and the manufacturer's directions should be followed in making up solutions of the desired concentration. Concentrations of available chlorine should be checked periodically by using one of the accepted test procedures. Alkaline hypochlorites are slower in germicidal action than are the less-alkaline compounds. However, their slowness in germicidal action is compensated for to a degree by their greater detergent action.

Hypochlorite solutions should be made up in a concentration of at least 100 ppm. of available chlorine, and must be discarded when the concentration drops below 50 ppm. of available chlorine. An exposure period of at least two minutes should be maintained when the temperature is at least 75°F. Under these conditions, an exposure of two minutes is considered adequate for all hypochlorites, including the slower, more-alkaline compounds. Hypochlorite bactericides cannot be relied upon in the presence of large amounts of milk or other organic matter. When spraying, in lieu of immersion, the above specified concentrations of available chlorine should be doubled. Hypochlorite solutions, once used, shall not be used again for bactericidal treatment, but may be used for other purposes.

The following table (from Public Health Reports, 65:503-12, Apr. 14, 1950) illustrates the effect of pH on the exposure period required for complete kill of non-spore-forming bacteria:

Table 12. Effect of pH on Bactericidal Action of Chloramine-T

pH of solution	Available chlorine (ppm)	Approximate contact period required (minutes)
7.0	250	2
8.5	250	20
11.5	250	300
7.5	750	2

Organic Chlorine Compounds - The bacterial action of chloramine T, the chlorinated hydantoins the chloramelamines, the chlorinated isocyanuriates and other organic forms of chlorine are significantly affected by pH.[1]

For example, with chloramine T solutions, the maximum pH which can be tolerated and still provide satisfactory results at 200 ppm. available chlorine is 7.2; at 100 ppm. concentration it is 6.8; and at the 50 ppm. level, 6.4. Thus, satisfactory results with formulations of the chemical based on the above equivalent germicidal activities cannot be expected with products which ionize in solutions to give pH values higher than 6.4. The practical value of chloramine T is limited to situations where long exposure periods are practicable, or where a low pH can be provided.

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1. Ortenzio, L. F., and Stuart, L. S., The Behavior of Chlorine-Bearing Organic Compounds in the AOAC Available Chlorine Germicidal Equivalent Concentration Test. Journal of the Association of Official Agricultural Chemists. Aug. 1959.

Chlorinated hydantoin formulations giving solutions of pH 7.0 and below should be satisfactory.

Satisfactory results in chlorinated isocyanuric acid solutions of pH values up to 9.5 can be expected.

The marked differences found in bactericidal activitiy of organic chlorine compounds over the pH range illustrate the necessity of establishing the conditions of use, including concentration, from experimental data.

Quaternary Ammonium Compounds - Continued field use has established that certain quaternary ammonium compounds are effective bactericides for the treatment of milk utensils, containers, and equipment. The bactericidal effectiveness of specific quaternary ammonium compounds varies and is influenced by the chemical nature and concentration of active agent, temperature, pH, exposure time, and by interfering substances present in natural waters. It has been established that the interference of natural waters is due principally to bicarbonates, sulphates, and chlorides of calcium and magnesium.[2]

Ferrous bicarbonate may also interfere to a lesser degree but its interference is minimized when the iron is oxidized. Any treatment which tends to precipitate, remove or inactivate calcium or magnesium reduces this interference as do increased pH and temperature.

Products containing n-alkyl (C_8-C_{18}) dimethyl benzyl ammonium chlorides, n-alkyl (C_{14} - C_{18}) dimethyl benzyl ammonium chlorides, alkyl dimethyl dichlorobenzyl ammonium chlorides and n-alkyl (C_{12} - C_{18}) dimethyl ethylbenzyl ammonium chlorides are effective in waters ranging from 550 to 1,100 ppm. hardness without added sequestering agents. Other quaternary products such as diisobutyl phenoxy ethoxy ethyl dimethyl benzyl ammonium chloride and methyl dodecyl benzyl trimethyl ammonium chloride-methyl dodecyl xylene bis (tri-methyl ammonium chloride) require compounding with sufficient sodium tripolyphosphate to raise their hard water ceiling levels to a minimum of 500 ppm. hardness at use concentrations. By proper formulation, however, levels up to 1,200 ppm. are possible. The above products have been found to be bactericidally effective when used (1) at concentrations of 200 ppm. or more, (2) at pH levels of 5.0 or higher, (3) at temperatures of 75° F. or higher, and (4) for a 30-second exposure period.

The above-named compounds without sequestering agents are also effective within certain limits of water hardness under the conditions of use enumerated above: however, the level of hardness at which bactericidal activity is reduced below that necessary for effective treatment, varies among the four named compounds and may be influenced by other ingredients in a proprietary formulation. Accordingly, the limiting hardness should be established for the use of each quaternary ammonium product. Unless stated on the label,[3] the health officer should request such information from the manufacturer.

Bacteriological data should be used to establish the usefulness of the above named quaternary ammonium compounds and sequestering agents and any others (1) at temperatures less than 75° F., (2) at a pH below 6.0, or (3) when combined with a compatible sequestering agent in waters above 500 ppm. of hardness, or (4) without, or with less than, the specified amount of sequestering agent. Suggested methods and criteria are given in the following subsection on Other Chemical Sanitizers.

Iodine Compounds - Another type of halogen sanitizer that has been found effective consists of a combination of iodine with certain nonionic substances. Although iodine is only slightly

2. Chambers, Kabler, Bryant, Chambers, and Ettinger, Bacterial Efficiency of Q.A.C. in Different Waters. Public Health Reports, 70:545-554. June 1955.
3. Bactericides shipped interstate are subject to the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act and their labels must be registered with the U.S. Department of Agriculture.

soluble in water and is volatile, in combination with nonionic wetting agents as an iodophor, it is readily soluble in water and is less volatile. When diluted for use, iodophors have a low pH which enhances their germicidal qualities. Increasing the temperatures of a sanitizing solution containing iodophors also increases its effectiveness, but above 120° F. iodine volatilizes, resulting in a decrease in solution strength.

In solution, iodophors are yellow or amber in color and the intensity is proportional to the concentration of iodine. Concentrations of 12.5 ppm. when used as a bactericide only and 25 ppm. when used as a detergent-sanitizer have been found effective. The concentration of iodine can be determined by titration with sodium thiosulfate, and color tests for field use are available. Since the bactericidal properties of different proprietary formulations may vary because of differences in ingredients and pH, their effectiveness may be evaluated by the bacteriological testing.

Detergent-Sanitizers - Bactericides are sometimes combined with detergents in proprietary formulations for the cleaning and bactericidal treatment of milk containers, utensils, and equipment in a single operation. Such use has been reported to be effective under certain conditions for the cleaning and bactericidal treatment of dairy farm equipment, milk-transportation tanks, and similar equipment.

The limitations of detergent-sanitizer combinations should be understood if they are to be used effectively. Certain sanitizers and detergents cannot be combined in solution without impairment of bactericidal properties, cleaning properties, or both. In addition, the activity of a detergent-sanitizer is likely to be reduced more rapidly by the presence of milk solids and other organic matter in a combined operation than when bactericidal treatment is a separate process which follows cleaning.

These factors tend to point up the fact that the usefulness of a detergent-sanitizer for the combined cleaning and sanitizing treatment of milk-contact surfaces is dependent on both the composition of the product and its intended use.

"Single-step" operations are actually considered most dependable when the amount of detergent-sanitizer can be carefully proportioned to the exact needs of the equipment involved, assuring effective cleaning and sanitizing, while minimizing the chance of residual chemical deposits on the equipment treated.

Further, and of equal importance to the above, is the need for the protection between treatment and use of all milk contact surfaces so sanitized. The application of untreated rinse water; the handling of equipment, as in the assembly of milking machines on farms or piping systems in milk plants; and the exposure of treated surfaces to airborne contamination through extended storage periods all tend to downgrade the values suggested for detergent-sanitizers.

These precautions are suggested where detergent-sanitizers are used:

1. Equipment to be treated should be thoroughly prerinsed.

2. Solutions should be prepared and used according to manufacturer's directions.

3. Treated equipment which is exposed to any of the hazards of contamination described above should be resanitized prior to use.

Other Chemical Sanitizers - Bactericides other than those described in the previous sections are also available which are suitable for use on milk equipment. Compounds containing bromine and iodine have been found to be effective for bactericidal treatment. In addition, other types of chemical agents are being compounded into proprietary formulations for the bactericidal treatment of milk equipment; however, their bactericidal effectiveness varies with specific formulations. Such compounds should be safe, and the recommended conditions of usage should provide bactericidal treatment at least equal to that given by 50 ppm. of chlorine as hypochlo-

rite at pH 10.0, at a temperature of 75° F., and with an exposure period of 1 minute.[4]

Sanitizing solutions should be prepared at a concentration such as to provide bacterial effectiveness (for circulation and immersion applications) equivalent to that of hypochlorite solutions at a concentration of 50 ppm. of available chlorine.

The bactericidal efficiency of chemical compounds may be evaluated without direct comparison to chlorine. Suitable data may be obtained by use of a bacteriological test procedure such as that proposed by Weber and Black,[5] or the Chambers[6] modification thereof. These tests provide better comparative data at an endpoint somewhat less than total kill of the test cultures. Therefore, the test time is less than 1-minute exposure period prescribed in Section 7 of this Ordinance. Bactericides which, in recommended concentration, produce a 99.999-percent kill of 75-125 million E. coli ATTC 11229 and of 75-125 million M. pyogenes var. aureus ATCC 6538, within 30 seconds at 70°-75° F., should be considered satisfactory. Swab tests of treated equipment do not furnish sufficient data for this purpose. Valid data can be obtained only when stock cultures and suspensions of the test organisms are prepared in a manner that uniformly maintains their normal level of resistance to germicidal action. Periodic checks to determine the consistency of test results, using a well known chemical such as phenol, is helpful in this regard. The importance of adhering strictly to the composition of mediums and manner of transplanting cultures specified in the test procedures cannot be overemphasized.

Sanitization of Assembled Equipment

Steam

When steam is used, each group of assembled piping shall be treated separately by inserting the steam hose into the inlet and maintaining steam flow from the outlet for at least 5 minutes after the temperature of the drainage at the outlet has reached 200° F. (The period of exposure required here is longer than that required for individual cans, etc., because of the heat lost through the large surface exposed to the air.) Covers must be in place during treatment.

Hot Water

Hot water may be used by pumping it through the inlet if the temperature at outlet end of the assembly be maintained to at least 170° F. for at least 5 minutes.

Chemicals

When chlorine or another chemical solution is used, the solution appearing at the outlet end shall show in excess of the minimum required strength. The chemical solution shall be pumped through the entire equipment for at least 1 minute. Unions and other connectors should be slightly loosened to permit treatment of gaskets and threads, except on lines cleaned-in-place. Surfaces which are not reached by the chemical solution shall be treated with steam as previously described, spray application of chemical solution, or by other acceptable means. Header ends and connecting piping of cabinet coolers should not be overlooked, since condensation from them may enter the collecting trough. Chemical sanitizing solutions should be prepared fresh for each use.

Treatment of Equipment Other Than Bottles and Pails

The treatment of milk cans, coolers, bottling machines, milking machines, other equipment, and all parts thereof, requires special consideration. Large equipment may be treated by thorough swabbing with a bactericidal solution of adequate strength, allowing the solution film to remain at least 1 minute. Rubber milking machine parts can be satisfactorily treated by immersion for 5 minutes in water at a temperature of at least 170° F. They may also be left in a sanitizing solution until the next milking, or treated by filling with or immersing in a 0.5 percent lye solution. Before further use, the lye solution should be drained off and the parts

4. Criteria for the Selection of Germicides, American Journal of Public Health, 51: 1054-60, July 1961.
5. American Journal of Public Health, 38: 1405-17, 1948.
6. Chambers, C.W., A Procedure for Evaluating the Efficiency of Bactericidal Agents, Journal of Milk and Food Technology, 19: 183-187, July 1956.

rinsed and sanitized as part of the assembled milking system. Fresh lye solution must be used for each storage period.[7]

Sanitizer Strength and Water Hardness Tests

Tests for Chlorine Concentration

Three types of field tests are satisfactory for chlorine concentration determinations:

Starch-Iodide Method (iodometric). - This test makes use of the fact that chlorine displaces iodine from potassium iodide in an acid solution (low pH). See general discussions in Standard Methods for the Examination of Water and Wastewater, Eleventh Edition, American Public Health Association. Iodine, plus starch, forms a blue color which is removed (decolorized) by the addition of standard sodium thiosulphate. The quantity of standard sodium thiosulphate required to remove the starch-iodine color is a measure of the chlorine present.

Field kits are available which give satisfactorily accurate reading of available chlorine. In some of these kits, the starch and potassium iodide are mixed in dry form for convenience of handling. Some use a liquid acid while others employ, for convenience, a crystalline one, such as sulphamic acid. The sodium thiosulphate is unstable unless a preservative be added. Some test kits make use of a preserved standardized sodium thiosulphate so that one drop of solution is equivalent to 10 ppm. of available chlorine. Tests kits should be checked periodically against standardized chlorine solutions.

Orthotolidine Colorimetric Comparison - This test is based on the fact that orthotolidine, which is colorless, forms an orange-brown colored compound when added to chlorine. The depth of color is a measure of the amount of chlorine present. A concentration of 20 ppm. of available chlorine causes a precipitate. Consequently, solutions which are concentrated must be diluted, usually at least 1:10 with chlorine-free water. Specific directions and color standards for comparison are included in test kits. Such test kits are available commercially. Color develops more slowly with alkaline hypochlorites than with the less alkaline compounds. Chloramines are considerably slower than alkaline hypochlorites in color formation, usually requiring at least 5 minutes.

Indicator Paper Test - The indicator paper test is widely used in situations where a high degree of accuracy is not required. It is a convenient, rapid, and generally a useful screening device. Ranges of chlorine concentration are indicated by the color developed on the test paper (usually starch-iodide impregnated) as it is immersed in the solution being tested.

Indicator papers are subject to rather rapid deterioration, especially if they be stored in a damp or chemically adverse environment. Their accuracy also suffers when they are handled excessively, especially if the operator's hands have been exposed to detergents, sanitizers, or other chemically active substances.

Tests for Quaternary Ammonium Compounds

Test kits are available which give satisfactory accurate readings within the range of recommended quaternary concentrations.

In some, the reagents are tableted for convenience of handling; others make use of test papers. Where the sanitizing solution is essentially clear and free from organic contamination, the above chemical test procedures will measure the amount of bactericidally active quaternary present during or after use. Where organic contamination is apparent, as evidenced by cloudiness in the sanitizing solution, the test sample should be heated to boiling for at least 5 minutes, and the supernatant liquid made up to volume with water and then removed for testing by pipetting or decantation in order to differentiate between the total amount of quaternary present and the amount bactericidally active.[8] If there be reason to verify the concentration of the stock quaternary solution from which the standardized solutions are made, a laboratory procedure such as that of Furlong and Elliker may be used.[9]

7. Jensen, J. M., Practical Sanitation in Caring for Milking Machines. Michigan Circular Bulletin No. 218. Michigan State University, East Lansing, Michigan. October 1950.

8. Law, McNulty and Rakus, Development of a procedure for Chemical Assay of the Bacterially Active Ingredient in Quaternary Ammonium Sanitizing Solutions. Manufacturing Chemist and Aerosol News. November 1964. Lautier Fils Ltd., London.

9. Journal of Dairy Science, 36: 225-234, March 1953.

Tests for Water Hardness

The water to be used for preparing solutions should, if pertinent, be within the range of hardness in which the proprietary formulation to be used is effective. Hardness may be determined by either the Hardness by Calculation Method or the Versenate Test (EDTA, titration method, ammonium buffer procedure), as described in Standard Methods for the Examination of Water and Wastewater, published by the American Public Health Association.

Tests for Hydrogen-ion Concentration

Hydrogen-ion concentration (pH) has a pronounced effect on the activity of sanitizing solutions. Consequently, solutions must be maintained in the pH range within which the bacterial agent is effective. In most cases, the pH of the solution is dependent upon the buffering action of the compound used. The pH of bactericide solutions can best be determined electrometrically, using the glass electrode. However, for a field test, colorimetric methods are more applicable. Two types of test kits for such determinations are available commercially. Colorimetric readings should be made immediately, because of the tendency toward oxidation and decolorization of the indicator. Such indicators as brom thymol blue, cresol red, thymol blue, or others are satisfactory, depending upon the pH range desired.

HTST Pasteurization*

Operation of HTST System

HTST pasteurization has become important to the dairy industry because of the operating efficiencies which it affords. Properly operated, these units allow high volume of production in a minimum of processing space.

The ability of HTST pasteurizers to assure a safe, finished product hinges on the reliability of the time-temperature-pressure relationships which must prevail whenever the system is in operation. It is important that the plant operator understand the HTST process in order to maintain proper surveillance over the equipment. The basic flow pattern is described below:

1. Cold raw milk, in a constant level supply tank, is drawn into the regenerator section of the HTST pasteurizer.**

2. In the regenerator section, the cold raw milk is warmed to approximately 135° F. by hot pasteurized milk flowing in a counter current direction on the opposite sides of thin stainless steel surfaces.

3. The raw milk, still under suction, passes through a positive displacement timing pump which delivers it under pressure through the rest of the HTST pasteurization system.

4. The raw milk is pumped through the heater section where hot water or steam on opposite sides of thin stainless steel surfaces heats the milk to a temperature of at least 161° F.

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*The Vacreator is a short time high temperature (194° F.) pasteurizer operated on a vacuum principle and steam treatment. The short time exposure to heat, the removal of oxygen, and the exclusion of harmful light rays during pasteurization avoid damage to vitamins, and change in the normal character of milk constituents. This method of operation also favors the removal of undesirable flavor substances.

**Note.--Some operators prefer to bypass the regenerator when starting. Under this system, cold milk is drawn directly through the timing pump (step 3) and into the heater section. The remaining steps are performed without exception. This bypass arrangement facilitates and speeds up the starting operation. After forward flow is established at the flow-diversion valve, the bypass, which may be manually or automatically controlled, is not used and the raw milk flows through the regenerator. A second start-up technique involves the use of sanitizer solution at 170° F. This is passed through the complete unit and followed immediately by milk. Dilution of the first milk does occur, however, and care must be taken to prevent this from being packaged.

5. The milk, at pasteurization temperature, and under pressure, flows through the holding tube where it is held for at least 15 seconds. (The maximum velocity of the milk through the holding tube is governed by the speed of the timing pump, the diameter and length of the holding tube, and surface friction.)

6. After passing the sensing bulbs of an indicating thermometer and a recorder-controller, the milk passes into the flow-diversion valve which automatically assumes a forward-flow position if the milk passes the recorder-controller bulb at the preset cut-in temperature (i.e., 161° F. or higher). The valve automatically assumes the diverted-flow position if the milk passes the recorder-controller bulb below the preset cut-in temperature (i.e., 161° F.).

7. Improperly heated milk flows through the diverted-flow line back to the raw milk constant level supply tank.

8. Properly heated milk flows through the forward-flow line to the pasteurized milk regenerator section where it serves to warm the cold raw milk and, in turn, is cooled to approximately 90° F.

9. The warm milk passes through the cooling section, where coolant, on the sides of thin stainless steel surfaces opposite the pasteurized milk, reduces its temperature to 40° F. and below.

10. The cold pasteurized milk then passes to a storage tank or vat to await packaging.

HTST Pasteurizers Employing Milk-to-Milk Regenerators With Both Sides Closed to the Atmosphere (Figures 1, 2, 3, 4).

Item 16p (C) of Section 7 establishes standards for regenerators. These standards insure that the raw milk will always be under less pressure than pasteurized milk in order to prevent contamination of the pasteurized milk in the event flaws should develop in the metal or the joints separating it from the raw milk. An explanation of regenerator specifications is given below:

During normal operation (i.e., while the timing pump is operating), raw milk will be drawn through the regenerator at subatmospheric pressure. The pasteurized milk in the milk-to-milk regenerator will be above atmospheric pressure. The required pressure differential will be assured when there is no flow-promoting device downstream from the pasteurized milk side of the regenerator to draw the pasteurized milk through the regenerator, and the pasteurized milk downstream from the regenerator rises to at least a 1-foot elevation above the highest raw milk level downstream from the constant level tank, and is open to the atmosphere at this or a higher elevation, as required in item 16p (C) 2.

During a shutdown (i.e., when the timing pump stops), the raw milk in the regenerator will be retained under suction, except as this suction may be gradually relieved by possible entrance of air drawn through the regenerator plate gaskets, from the higher outside atmospheric pressure. With a free draining regenerator, as required under item 16p (C) 7,

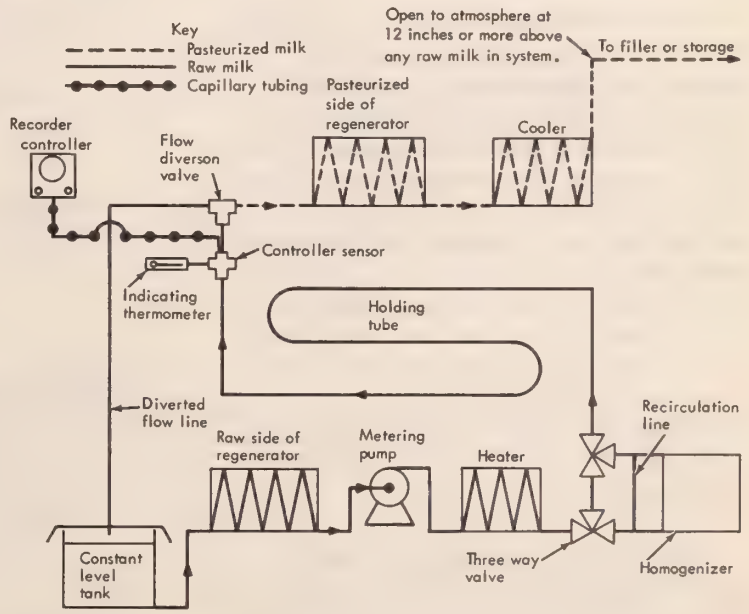

Figure 1. Milk-to-milk regeneration--Homogenizer upstream from holder.

the raw milk level in the regenerator may drop slowly, depending on the tightness of the gaskets, ultimately falling below the level of the plates to the product level in the raw milk supply tank. However, under these conditions, as long as any raw milk remains in the regenerator, it will be at subatmospheric pressure.

During shutdown, the pasteurized milk in the regenerator is maintained at atmosphere pressure or above by meeting the elevation requirement of item 16p (C) 2. Pressure greater than atmospheric is maintained when the level of pasteurized milk is at or above the required elevation; loss of pressure due to suction is prevented by prohibiting a downstream pump.

Any backflow of milk through the flow-diversion valve would lower the pasteurized milk level during pump shutdowns, thus tending to reduce the pressure on the pasteurized milk side of the regenerator. A flow-diversion valve cannot be relied upon to prevent backflow in such instances, because during the first few minutes following a pump shutdown, the milk is still at a sufficiently high temperature to keep the diversion valve in the forward-flow position. Compliance with the provisions of item 16p (C) 2 and 3, however, will insure a proper pressure differential in the regenerator.

At the beginning of a run, from the time raw milk or water is drawn through the regenerator, until the pasteurized milk or water has risen to the elevation specified on item 16p (C) 2, the pasteurized milk side of the regenerator is at atmospheric pressure or higher. Even if the metering pump should stop during this period, the pressure on the pasteurized milk side of the regenerator will be greater than the subatmospheric pressure on the raw milk side, assured by compliance with item 16p (C) 2 and 3, as long as any raw milk remains in the regenerator.

When a raw milk booster pump is incorporated into the HTST system, item 16p (C) 5 requires, in part, that automatic means shall be provided to

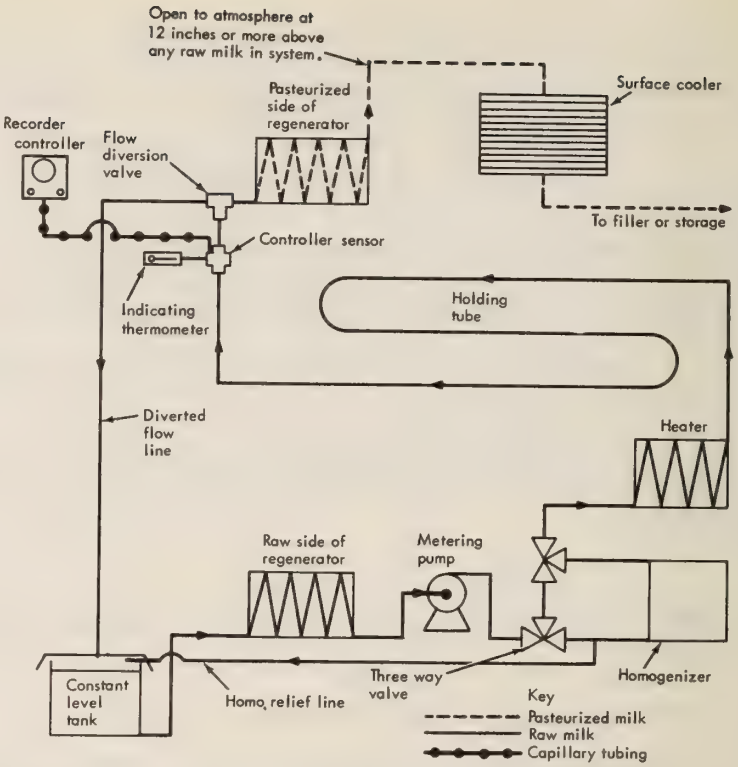

Figure 2. Milk-to-milk regeneration--Surface cooler.

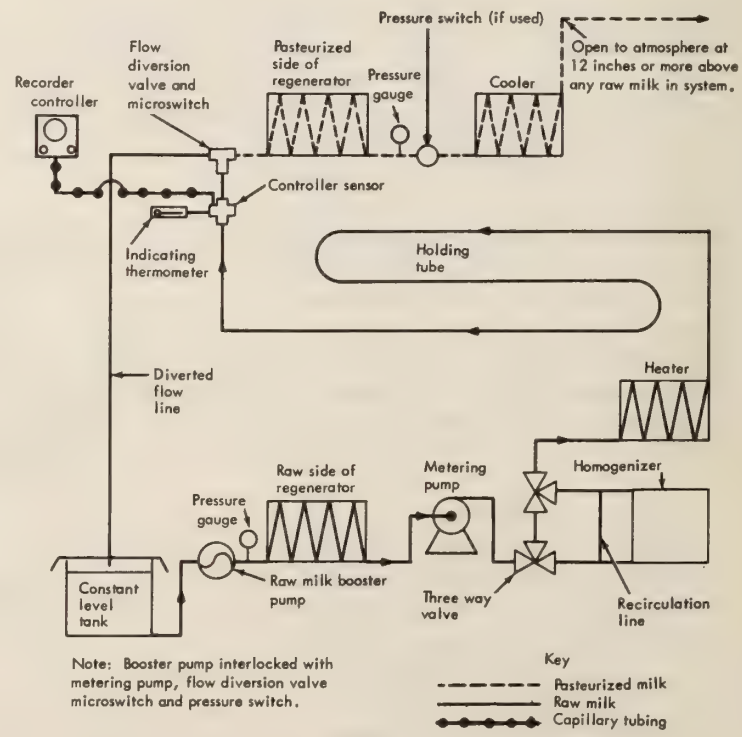

Figure 3. Milk-to-milk regeneration--Booster pump.

assure, at all times, the required pressure differential between raw and pasteurized milk in the regenerator before the booster pump can operate. The most common control employed to accomplish this is a sanitary pressure switch installed at or downstream from the pasteurized milk outlet of the regenerator. The pressure switch is adjusted to energize the booster pump only after the pasteurized milk pressure in the regenerator exceeds, by at least one (1) pound per square inch, the maximum operating pressure developed by the booster pump.

The setting and checking of the pressure switch used to control the proper operation of the raw milk booster pump is described in Test 9, "Setting of Control Switches - Regenerator Pressure."

As an alternative control to the use of the pressure switch, the adjustable time delay relay in conjunction with a hydrostatic head, has been effectively used in HTST systems equipped with raw milk booster pumps of relatively low capacity. Such time delay relay provides a predetermined time lapse between the moment the flow-diversion valve assumes the forward-flow position and the moment the booster pump is energized. The time lapse required is that necessary for the forward flow of milk through the regenerator and cooler to rise to a height sufficiently above the booster pump outlet to provide a pressure at least one pound greater than the maximum pressure developed by the booster pump. The pasteurized milk pipeline is vented to the atmosphere at or above the necessary vertical rise.

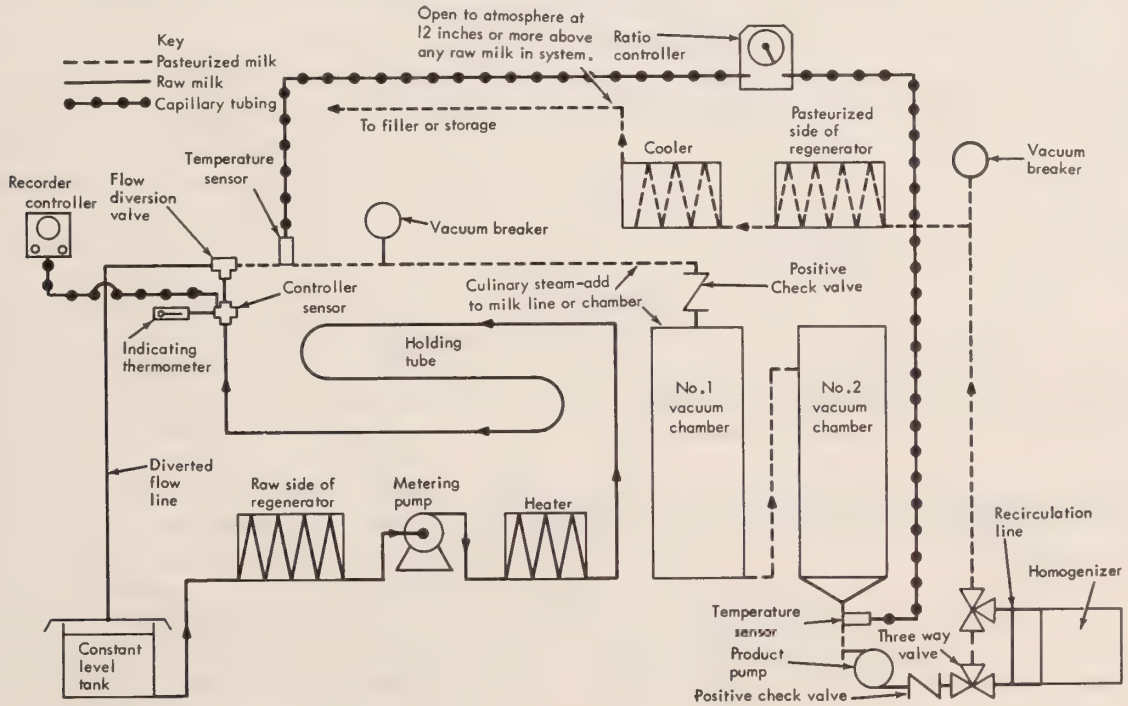

Figure 4. Milk-to-milk regeneration — Homogenizer and vacuum chambers downstream from flow dispersion valve.

Thermometer Specifications

Indicating Thermometers for Batch Pasteurizers

Mercury-actuated; direct-reading; contained in a corrosion-resistant case which protects against breakage and permits easy observation of column and scale; filling above mercury, nitrogen, or other suitable gas.

Magnification of Mercury Column. —To apparent width of not less than one-sixteenth of an inch.

Scale. —Shall have a span of not less than 25° F. including the pasteurization temperature plus and minus 5° F.; graduated in 1° F. divisions with not more than 16° F. per inch of span; protected against damage at 220° F.

Accuracy. —Within 0.5° F., plus or minus through the specified scale span. (See Tests for Thermometers)

Submerged Stem Fittings.—Pressure-tight seat against inside wall of holder; no threads exposed to milk; location of seat to conform to that of a 3-A Sanitary Standard wall-type fitting or other equivalent sanitary fitting.

Bulb. —Corning normal or equally suitable thermometric glass.

Indicating Thermometers Located on Pasteurization Pipelines

Type. —Mercury-actuated; direct-reading; contained in corrosion-resistant case which protects against breakage and permits easy observation of column and scale; filling above mercury, nitrogen, or equally suitable gas.

Magnification of Mercury Column. —To apparent width of not less than one-sixteenth of an inch.

Scale. —Shall have a span of not less than 25° F., including the pasteurization temperature plus and minus 5° F.; graduated in 0.5° F. divisions with not more than 8° F. per inch of scale; protected against damage at 220° F.

Accuracy.—Within 0.5° F., plus or minus throughout specified scale span.

Stem Fittings. —Pressure-tight seat against inside wall of fittings; no threads exposed to milk; distance from underside of ferrule to top of the sensitive portion of bulb not less than 3 inches.

Thermometric Response. —When the thermometer is at room temperature and then is immersed in a well-stirred water bath 19° F. or less above the pasteurization temperature, the time required for the reading to increase from water bath temperature minus 19° F. to water bath temperature minus 7° F. shall not exceed 4 seconds.

Bulb. —Corning normal, or equally suitable thermometric glass.

Airspace Indicating Thermometer for Batch Pasteurizers

Type. —Mercury-actuated; direct-reading; contained in corrosion-resistant case which protects against breakage and permits easy observation of column and scale; bottom of bulb chamber not less than 2 inches, and not more than 3 1/2 inches, below underside of cover; filling above mercury, nitrogen, or equally suitable gas.

Magnification of Mercury Column. —To apparent width of not less than one-sixteenth of an inch.

Scale. —Shall have a span of not less than 25° F., including 150° F. plus or minus 5° F.; graduated in not more than 2° F. divisions, with not more than 16° F. per inch of scale; protected against damage at 220° F.

Accuracy.—Within 1° F., plus or minus, throughout the specified scale span.

Stem Fittings.—Pressure-tight seat or other suitable sanitary fittings. No threads exposed.

Recording Thermometers for Batch Pasteurizers

Case.—Moistureproof under normal operating conditions in pasteurization plants.

Scale. —Shall have a span of not less than 20° F., including pasteurization temperature, plus and minus 5.0° F., graduated in temperature-scale divisions of 1° F. spaced not less than one-sixteenth of one inch apart between 140° F. and 155° F., graduated in time scale divisions of not more than 10 minutes, having a chord or straight-line length of not less than one-quarter inch between 145° F. and 150° F.: Provided, That on vats used solely for 30-minute pasteurization of milk products at temperatures above 160° F., 2° F. divisions may be used one-sixteenth of an inch apart, with temperature accuracy 2° F. plus or minus.

Temperature Accuracy. —Within 1° F., plus or minus, between 140° and 155° F.

Time Accuracy.—The recorded elapsed time, as indicated by the chart rotation, shall not exceed the true elapsed time, as compared to an accurate watch, over a period of at least 30 minutes at pasteurization temperature. Recorders for batch pasteurizers may be equipped with spring operated or electrically operated clocks.

Pen-Arm Setting Device. —Easily accessible; simple to adjust.

Pen and Chart Paper.—Pen designed to give line not over one-fortieth of an inch wide; easy to maintain.

Temperature Sensing Device. —Protected against damage at temperature of 220° F.

Submerged Stem Fitting.—Pressure-tight seat against inside wall of holder, no threads exposed to milk or milk products. Distance from underside of ferrule to the sensitive portion of the bulb to be not less than 3 inches.

Chart Speed. —A circular chart shall make one revolution in not more than 12 hours in 1 day. Two charts shall be used if operations extend beyond 12 hours in 1 day. Circular charts shall be graduated for a maximum record of 12 hours. Strip-charts may show a continuous

recording over a 24-hour period.

Recorder Controllers for Continuous Pasteurizers

Case.—Moistureproof under normal operating conditions in pasteurization plants.

Chart Scale.—Shall have a span of not less than 30° F., including the temperature at which diversion is set, plus and minus 12° F., graduated in temperature scale divisions of 1° F. spaced not less than one-sixteenth of one inch apart at the diversion temperature, plus or minus 1.0° F., graduated in time scale divisions of not more than 15 minutes, having an equivalent 15 minute chord or straight-line length of not less than one-fourth inch at the diversion temperature, plus or minus 1.0° F.

Temperature Accuracy. —Within 1° F., plus or minus, at the temperature at which the controller is set to divert, plus or minus 5.0° F.

Power Operated. —All recorder controllers for continuous pasteurization shall be electrically operated.

Pen-Arm Device. —Easily accessible; simple to adjust.

Pen and Chart Paper.—Pen designed to give line not over one-fortieth of an inch wide; easy to maintain.

Temperature Sensing Device. —(Bulb, tube, spring, thermister) protected against damage at temperature of 220° F.

Submerged Stem Fitting. —Pressure-tight seat against inside wall of pipe; no threads exposed to milk or milk products; location from underside of ferrule to the sensitive portion of the bulb not less than 3 inches.

Chart Speed. —A circular chart shall make one revolution in not more than 12 hours in 1 day. Two charts shall be used if operations extend beyond 12 hours in 1 day. Circular charts shall be graduated for a maximum record of 12 hours. Strip-charts may show a continuous recording over a 24-hour period.

Frequency Pen. —The recorder-controller shall be provided with an additional pen-arm for recording, on the outer edge of the chart, the record of the time and temperature at which the flow-control device is in the forward flow, diverted flow, or stopped position. The chart time line shall correspond with the reference arc, and the recording pens shall rest upon the time line matching the reference arc.

Controller. —Cut-in and cut-out response independent of pen-arm movement.

Controller Adjustment. —Mechanism for adjustment of response temperature simple, and so designed that the temperature setting cannot be changed or the controller manipulated without detection by the health authority.

Thermometric Response. —With the recorder-controller bulb at room temperature and then immersed in a well stirred water bath at 7° F. above the cut-in point, the interval between the moment when the recording thermometer reads 12° F. below the cut-in temperature and the moment of power cut-in shall be not more than 5 seconds.

Indicating Thermometers Used in Storage Tanks and Rooms

Scale Range.—Shall have a span not less than 50° F. including normal storage temperatures plus or minus 5.0° F. with extension of scale on either side permitted; graduated in not more than 2.0° F. divisions.

Temperature Scale Divisions. —Spaced not less than one-sixteenth of an inch apart between 35° F. and 55° F.

Accuracy.—Within 2° F. plus or minus, throughout the specified scale range.

Stem.—Shall conform to 3-A sanitary Standards for Thermometer Fittings and Connections and Supplement No. 1 thereto.

Recording Thermometers Used in Storage Tanks

Case.—Moistureproof under operating conditions in processing plants.

Scale. —Shall have a scale span of not less than 50° F., including normal storage temperature plus or minus 5° F., graduated in not less than 2° F. divisions with not more than 40° F. per inch of scale; graduated in time scale divisions of not more than 1 hour having a chord or straight line length of not less than one-eighth of an inch at 40° F. Chart must be capable of recording temperatures up to 180° F. (Span specifications do not apply to extensions beyond 100° F.)

Temperature Accuracy.—Within 2° F. plus or minus, between specified range limits.

Pen-Arm Setting Device.—Easily Accessible; simple to adjust.

Pen and Chart Paper.—Designed to give line not over one-fortieth of an inch thick when in proper adjustment; easy to maintain.

Temperature Sensor.—Protected against damage at 212° F.

Stem Fitting. —Shall conform to 3-A Sanitary Standards for Thermometer Fittings and Connections and Supplement No. 1 thereto.

Chart Speed. —The circular chart shall make one revolution in not more than 7 days and shall be graduated for a maximum record of 7 days. Strip chart shall move not less than 1 inch per hour and may be used continuously for 1 calendar month.

Recording Thermometers on Mechanical Cleaning Systems

Location. —Temperature sensor in the return line downstream from processing equipment and all lines included in the cleaning-in-place process.

Case.—Moistureproof under operating conditions.

Scale. —Shall have a range of 60° F. to 180° F., with extensions of scale on either side permissible; graduated in time-scale divisions of not more than 15 minutes. Above 110° F., the chart is to be graduated in temperature divisions of not more than 2° F. spaced not less than one-sixteenth of an inch apart.

Temperature Accuracy.—Within 2° F. plus or minus, above 110° F.

Pen-Arm Setting Device. —Easily accessible; simple to adjust.

Pen and Chart Paper. —Designed to mark a line not over one-fortieth of an inch wide; easy to maintain.

Temperature Sensor.—Protected against damage at 212° F.

Stem Fitting. —Pressure-tight seat against inside wall of pipe; no threads exposed to solution.

Chart Speed. —Circular charts shall make one revolution in not more than 24 hours. Strip charts shall not move slower than 1 inch per hour. More than one record of the cleaning operation shall not overlap on the same section of the chart for either circular- or strip-type charts.

Pasteurization Equipment and Controls-Tests

Maximum-Self-Registering Thermometer

Type. —Maximum-self-registering, mercury actuated; pocket type, readily cleanable.

Magnification of Mercury Column. —To apparent width of not less than one-sixteenth inch.

Scale Range. —140° F. to 150° F. with extension on either side permitted. The 140° F. point to be not less than three-fourths inch above contraction. Protection against damage at 157° F.

Temperature Represented by Smallest Scale Division.— 0.2° F.

Number of Degrees per Inch of Scale. — Not more than six.

Accuracy.—Within 0.2° F., plus or minus, between 144° F. and 147° F. The accuracy shall be checked against a thermometer which has been tested for accuracy by the National Bureau of Standards.

Armor. —Thermometer, if armored, to be easily removable for cleaning; armor to be fenestrated; with suspension ring; scale to be visible without removing armor.

Bulb. —Corning normal or equally suitable thermometric glass.

Case.—Metal, provided with fountain pen clip.

The maximum-self registering test thermometer shall be checked occasionally by holding it in clear water approximately 145° F., reading the temperature while it is immersed, and again 1 minute after the thermometer has been removed from the water bath.

Pipeline Test Thermometer

Type.—Mercury actuated; readily cleanable, plain front, enameled back; length, 12 inches; standardized for 4-inch immersion; immersion point to be etched on stem, contraction chamber to be of narrow type, immediately above the bulb, not over 1 inch long; mercury to stand in contraction chamber at 32° F.

Scale Range. —142° F. to 168° F., with extension of scale on either side permitted; 142° F. point to be not less than 1 inch above immersion line. Protected against damage.

Temperature Represented by Smallest Scale Division. — 0.2° F.

Number of Degrees per Inch of Scale. —Not more than six.

Accuracy.—Within 0.2° F. plus or minus, throughout specified scale range. The accuracy

shall be checked against a thermometer which has been tested for accuracy by the National Bureau of Standards.

Carrying Case. —Felt-lined metal.

Bulb. —Corning normal or equally suitable thermometric glass.

Test Thermometer

Type. —Mercury-actuated; readily cleanable; plain front, enameled back; length 12 inches, immersion point to be etched on stem, mercury to stand in contraction chamber at 32° F.

Scale Range. —175° F. to 205° F., with extension of scale on either side permitted. Protected against damage at 220° F.

Temperature Represented by Smallest Scale Division. — 0.2° F.

Number of Degrees per Inch of Scale. —Not more than six.

Accuracy. —Within 0.2° F. plus or minus, throughout specified scale range. The accuracy shall be checked against a thermometer which has been tested by the National Bureau of Standards.

Bulb. —Corning normal or equally suitable thermometric glass.

General Purpose Thermometer

Type. —Pocket type; mercury-actuated.

Magnification of Mercury Column. —To apparent width of not less than one-sixteenth inch.

Scale Range. —30° F. to 212° F., with extension on either side permitted. Protected against damage at 220° F.

Temperature Represented by Smallest Scale Divsion. — 2° F.

Number of Degrees per Inch of Scale. —Not more than 52.

Accuracy. —Within 2° F. plus or minus, throughout the specified scale range. Checked periodically against a known accurate thermometer.

Case. —Metal, provided with a fountain pen clip.

Bulb. —Corning normal or equally suitable thermometric glass.

Electrical Conductivity Measuring Devices

Type. —Wheatstone bridge, Galvanometer, Milliammeter; manual or automatic.

Conductivity. —Capable of detecting change produced by the addition of 10 parts per million of sodium chloride, in water of 100 parts per million of hardness.

Electrodes. — Standard.

Automatic Instruments. —Electric clock, time divisions not less than two-tenths of 1 second.

Stopwatch

Type. —Pocket type, open face, hand indicating fractional seconds.

Accuracy. —Accurate to one-fifth of a second.

Hands. —Sweep hand, one complete turn every 60 seconds or less.

Scale. —Divisions of not over two-tenths of a second.

Crown. —Depression of crown starts, stops, and resets to zero.

Test Procedures

Equipment and field tests to be performed and samples to be taken by the health authority are listed and suitably referenced below. The results of tests shall be recorded on "Milk Plant Equipment Test Form," (PHS-723-2), or equivalent, and results filed in the office's permanent record.

Test 1. Indicating Thermometers - Temperature Accuracy

Reference. —Item 16p (D).

Application. —To all indicating thermometers used for measurement of milk temperature during pasteurization, including airspace thermometers.

Frequency. —Upon installation and once each 3 months thereafter.

Criteria. —Within 0.5° F. plus or minus, in a specified scale range.

Apparatus. — (a) Test thermometer meeting specifications, (b) Water bath and agitator, (c) Suitable means of heating water bath.

Method. —Both thermometers exposed to a water medium of uniform temperature. Indicating thermometer reading is compared to the reading of the test thermometer.

Procedure.—(a) Prepare 10 gallons of water in a milk can or vat by raising the temperature of the water to within a range of 3° F. of the appropriate pasteurization temperature or airspace temperature.

(b) Remove heat source; agitate water bath rapidly.

(c) Continue agitation. Insert indicating test thermometer to indicated immersion point during the test.

(d) Compare both thermometer readings at the temperature reading within the test range.

(e) Repeat comparison of readings.

(f) Record thermometer readings, thermometer identification, or location.

Corrective Action. —Do not run test if mercury column has been split or capillary tube is broken as thermometer should be returned to the factory for repair. When the indicating thermometer differs from the test thermometer by more than 0.5° F., the scale plate of the indicating thermometer should be adjusted to agree with the test thermometer. Retest the thermometer after adjustment.

Test 2. Recording Thermometers - Temperature Accuracy
Reference. —Item 16p (D).
Application. —To all recording and recorder-controller thermometers used to record milk temperatures during pasteurization.
Frequency.—Upon installation, at least once each 3 months and whenever recording pen-arm setting requires frequent adjustment.
Criteria.—Within 1° F. plus or minus, in specified scale range.
Apparatus. —Pasteurizer indicating thermometer previously tested against a known accurate thermometer, two 10-gallon milk cans, or suitable vats or containers, agitator, suitable means of heating water baths and ice.
Method.—The testing of a recording thermometer for temperature accuracy involves the determination of whether or not the temperature pen-arm will return to within 1° F. of its previous setting after exposure to boiling water and melting ice.
Procedure.—(a) Adjust the recording pen to read exactly as the previously tested indicating thermometer in the temperature range for the pasteurization process being used after a stabilization period of 5 minutes at a constant temperature. The water bath shall be rapidly agitated throughout the stabilization period.

(b) Prepare one water bath by heating to the boiling point. Maintain temperature. Prepare a second container with melting ice. Place water baths within working distance of the recorder sensing element.

(c) Immerse the sensing element of recorder in boiling water for not less than 5 minutes.

(d) Remove the sensing element from the boiling water and immerse in melting ice for not less than 5 minutes.

(e) Have a can of water adjusted to a temperature within the testing range for the pasteurization process being used. Allow a 5-minute stabilization period for both indicating and recording thermometers. Compare readings of 1° F. plus or minus, indicator thermometer reading.

(f) Record results.

Corrective Action. —If the pen does not return to 1° F. plus or minus of indicating thermometer reading, the recording thermometer should be repaired.

Test 3. Recording Thermometers - Time Accuracy
Reference. —Item 16p (D).

Application. —To all recording and recording-controller thermometers used to record time of pasteurization.

Frequency.—Upon installation and at least once each 3 months thereafter.

Criteria.—The recorded time of pasteurization shall not exceed the true elapsed time.

Apparatus. —(a) A watch graduated at intervals not to exceed 1 minute, and accurate to within 5 minutes in 24 hours.

(b) A pair of dividers, or any other suitable device for measuring short distances.

Method.—Comparison of the recorded time over a period of not less than 30 minutes with a watch of known accuracy. For recorders utilizing electric clocks, check cycle on face plate of clock with known cycle; observe that clock is in operating condition.

Procedure.—(a) Determine if chart be appropriate to recorder.

(b) Inscribe reference mark at the pen point on the recorder chart at the start of the holding period and record the time.

(c) At the end of 30 minutes by the watch, inscribe a second reference mark at the pen point position on the chart.

(d) Determine the distance between the two reference marks and compare the distance with the time-scale divisions on the record chart at the same temperature.

(e) For electric clocks, remove face plate, compare cycle specification on face plate with the current cycle utilized.

(f) Enter finding on chart and initial. Record results.

Corrective Action. —If recorded time be incorrect, the clock should be adjusted or repaired.

Test 4. Recording Thermometers - Check Against Indicating Thermometer

Reference. —Item 16p (D).

Application. —To all recording thermometers used to record milk temperatures during pasteurization.

Frequency.—At least once each 3 months by health authority; daily by plant operator.

Criteria.—Recording thermometer shall not read higher than corresponding indicating thermometer.

Apparatus. —No supplementary materials required.

Method.—This test requires only that the reading of the recording thermometer be compared with that of the indicating thermometer at a time when both are exposed to milk at a stabilized pasteurization temperature.

Procedure. —(a) While milk is at a stabilized pasteurization temperature, read indicating thermometer.

(b) Immediately inscribe on the recording-thermometer chart a line intersecting the recorded temperature are at the pen location; record on the chart the indicating thermometer temperature; initial.

(c) Record results.

Corrective Action. —If recording thermometer should read higher than indicating thermometer, the pen should be adjusted by the operator.

Test 5. Flow Diversion Valve - Proper Assembly and Function

Reference. —Item 16p (D).

Application. —To all flow diversion valves used with continuous-flow pasteurizers.

Frequency.—Upon installation and at least once each 3 months thereafter.

Criteria.—The flow diversion valve shall function correctly in operating situations and shall de-energize the metering pump in the event of malfunction or incorrect assembly.

A. Leakage Past Valve Stem: Apparatus. —Open end wrench for sanitary fitting.

Method.—Observe the valve seat of the flow-diversion valve for leakage.

Procedure.—With the HTST system operating with water, place the flow-diversion valve in diverted flow position. Disconnect the forward flow piping; observe the valve seat for leakage.

Corrective Action. —If leakage be noted, valve must be dismantled and defective gaskets replaced or other suitable repairs made.

B. Operation of Valve Stem: Apparatus. —Open end or adjustable wrench.

Method. —Observe flow-diversion valve stem for ease of movement.

Procedure. —Tighten stem packing nut as much as possible. Operate HTST system; place valve in forward and diverted flow several times. Note freedom of action of valve stem.

Corrective Action. —If valve action be sluggish, suitable adjustment or repair shall be made to permit stem to act freely in all positions with packing nut fully tightened.

C. Valve Assembly: Apparatus. —Open end wrench for sanitary fittings.

Apparatus. —Open end wrench for sanitary fittings.

Method.—Observe function of metering pump when flow-diversion valve is improperly assembled.

Procedure. —(a) With HTST system in operation, unscrew by one-half turn, the 13H hex nut which holds the top of the valve to the valve body. This should de-energize the metering pump. This test should be run with no piping connected to the forward flow port of the valve since there can be sufficient force from the piping to keep the forward flow port tightly clamped even though the hex nut be loosened.

(b) With the HTST system in operation and the flow-diversion valve in the diverted position, remove the connecting key located at the base of the valve stem. The metering pump should be de-energized.

Corrective Action. —If metering pump fails to respond as indicated, an immediate check of the valve assembly and wiring are required to locate and correct the cause.

D. Manual Diversion (when booster pump is installed in the HTST system): Apparatus: None.

Method.—Observe the response of the system to manual diversion.

Procedure.—With the HTST system in operation and the flow-diversion valve in the forward flow position, press the manual diversion button located on the valve bonnet cover plate. This should (a) cause the valve to assume the divert position, and (b) de-energize the booster pump; the pressure differential between raw and pasteurized milk in the regenerator should be maintained.

Corrective Action. —If (a) and (b) above do not occur as described or the necessary pressure differential between raw and pasteurized milk be not maintained, the assembly and wiring of the HTST system must be immediately reviewed and the indicated deficiencies corrected.

E. Response Time: Apparatus: Stopwatch. The stopwatch should be used to determine that the response time interval does not exceed 1 second.

Method.—Determine the elapsed time between the instant of the activation of the control mechanism at cut-out temperature on declining temperature and the instant the flow-diversion valve takes the fully diverted flow position.

Procedure.—(a) With water bath at a temperature above cut-out temperature, allow the water to cool gradually. At the moment the cut-out mechanism is activated, start the watch and the moment the flow-diversion valve takes the fully diverted position, stop the watch.

(b) Record results.

Corrective Action. —Should response time exceed 1 second, immediate corrective action must be taken.

Test 6. Leak Protector Valve

Reference. —Item 16p (D).

Application. —To all pasteurizer inlet, outlet, and flow-diversion valves required to be of the leak-protector type.

Frequency. —Upon installation and at least once each 3 months thereafter.

Criteria.—No leakage of milk past the valve seat in any closed position.

Apparatus. —No supplementary materials required.

Method. —By observing when the piping is disconnected from the valve outlet whether or not leakage past the valve seat occurs when milk pressure is exerted against the upstream face of the valve.

Procedure.—(a) During normal operation, while milk pressure is exerted against the valve inlet, fully close the valve and disconnect the outlet piping. In the case of flow-diversion valves, this should be done during diversion.

(Caution: Care must be taken to avoid contamination of the valves or the piping.)

(b) Observe whether or not any milk is leaking past the valve seat into the valve outlet.

(c) In the case of plug-type valves, turn the valve to the just-closed position, and examine for leakage into the valve outlet.

(d) Reconnect the outlet piping.

(e) Record identity of the valve, and findings, for office record.

Corrective Action. —If leakage past the valve seat should occur in any closed position, the valve plug should be reground, gaskets replaced, springs replaced or other necessary steps be taken to prevent leakage.

Test 7. Indicating Thermometers on Pipelines - Thermometric Response

Reference. —Item 16p (D).

Application. —To all indicating thermometers located on pipelines and used for determination of milk temperatures during pasteurization.

Frequency.—Upon installation and once each 3 months thereafter.

Criteria.—Four seconds under specified conditions.

Apparatus. —Pipeline test thermometer, stopwatch, water bath (10-gallon can), agitator, heat supply, and indicating thermometer from pasteurizer.

Method.—By measuring the time required for the reading of the thermometer being tested to increase 12° F. through a specified temperature range (temperature range must include pasteurization temperature). The temperature used in the water bath will depend upon the scale range of the thermometer to be tested.

Procedure.—(a) Immerse indicating thermometer in water bath heated to a temperature at least 19° F. higher than minimum scale reading on indicating thermometer. Bath temperature should be higher than maximum pasteurization temperature for which thermometer is used.

(b) Immerse indicating thermometer in bucket of cold water for several seconds to cool it.

Note. —Continuous agitation of water baths during the performance of steps (c), (d), and (e) is required. Elapsed time between end of step (a) and beginning of step (c) should not exceed 15 seconds so hot water bath does not cool significantly.

(c) Insert indicating thermometer in hot water bath to proper bulb immersion depth.

(d) Start stopwatch when indicating thermometer reads 19° F. below bath temperature.

(e) Stop stopwatch when indicating thermometer reads 7° F. below bath temperature.

(f) Record thermometric response time for office record.

Example: On a thermometer with a range of 150° F. to 175° F. used at a pasteurization temperature of 161° F., a water bath of 170° F. could be used. 19° F. below 170° F. would be 151° F.; 7° F. below 170° F. would be 163° F. Hence after immersing the thermometer, which had been previously cooled, in the 170° F. bath, the stopwatch is started when the thermometer reads 151° F. and stopped when it reads 163° F.

Note: The test included the pasteurization temperatures of 161° F. and 166° F.

Corrective Action. —If the response time should exceed 4 seconds, the thermometer should

be replaced or returned for repair.

Test 8. Recorder-Controller-Thermometer

Reference. —Item 16p (B).

Application. —To all recorder-controllers used in connection with continuous flow pasteurizers.

Frequency.— Upon installation and at least once each 3 months thereafter.

Criteria.—Five seconds, under specified conditions.

Apparatus. —Previously tested indicating thermometer (on pasteurizers), stopwatch, water bath (10-gallon milk can), agitator, heat supply.

Method. —Measure the time interval between the instant when the recording thermometer reads 12° F. below the cut-in temperature and the moment of cut-in by the controller. This measurement is made when the sensing element is immersed in a rapidly agitated water bath maintained at exactly 7° F. above the cut-in temperature.

Procedure. —(a) Check and, if necessary, adjust the pen-arm setting of the recording thermometer in the proper reference arc to agree with the indicating thermometer reading at pasteurization temperature.

(b) Determine the cut-in temperature of controller (Test No. 10), either while in normal operation or by using a water bath.

(c) Remove sensing element and allow to cool to room temperature.

(d) Heat water bath to exactly 7° F. above the cut-in temperature while vigorously agitating water bath to insure uniform temperature.

(e) Immerse recorder-controller bulb in water bath. Continue agitation during items (f) and (g) below.

(f) Start stopwatch when the recording thermometer reaches a temperature of 12° F. below the cut-in temperature.

(g) Stop stopwatch when the controller cuts in.

(h) Record thermometric response time for office record.

Corrective Action. —If the response should exceed 5 seconds, the recorder-controller should be repaired.

Test 9. Setting of Control Switches - Regenerator Pressure

Reference. —Item 16p (D).

A. Pressure Switches.— Used to control operation of booster pumps:

Application. — To all pressure switches controlling the operation of booster pumps on HTST pasteurizer systems employing regenerators.

Frequency.—Upon installation, each 3 months thereafter, after any change in the booster pump or the switch circuit, and/or whenever the pressure switch seal is broken.

Criteria.—The pump shall not operate unless there be at least a 1-pound pressure differential on the pasteurized milk side of the regenerator.

Apparatus. —Sanitary pressure gage and pneumatic testing device, for checking and adjusting pressure switch settings.

A simple inexpensive pneumatic testing device may be made from a discarded 2"-7BX sanitary tee, with two additional 13H nuts, one of which is provided with a 16A cap, drilled and tapped for a one-half inch galvanized iron nipple for the air connection. A host connection is made to a compressed air source in the plant by means of a snap-on fitting. The air pressure can be controlled by an inexpensive pressure reducing valve (range 0-60 p.s.i.g.) followed by a 1/2-inch globe type bleeder valve connected into the side outlet of a 1/2-inch tee installed between the pressure reducing valve and the testing device. The pressure switch to be tested is disconnected from the pasteurizer and connected to another of the outlets of the sanitary tee,

and the pressure gage is connected to the third outlet of the sanitary tee. By careful manipulation of the air pressure reducing valve and the air bleeder valve, the air pressure in the testing device may be regulated slowly and precisely. (In operating the device, care should be taken to avoid exposing the pressure switch and the sanitary pressure gage to excessive pressure which might damage them. This can be done by first closing off the air pressure regulating valve and opening fully the bleeder valve; these may then be manipulated slowly to bring the air pressure in the testing device within the desired range.) A test light of proper voltage can be placed in series with the pressure switch contact and in parallel with the electrical load (booster pump starter) so the actuation point may be readily determined. (This testing device is similar to that described in an article A Simple Pneumatic Tester for Checking and Setting Pressure Switches for HTST Booster Pump Control, Tom W. Proctor, Journal of Milk and Food Technology, vol. 24 No. 10, October 1961).

Method.—Check and make adjustment of pressure switch so as to prevent the operation of the booster pump unless the pressure on the pasteurized milk side of the regenerator is greater by at least 1 pound per square inch than any pressure that may be generated on the raw side.

Procedure. —

1. Determine maximum pressure of booster pump.

(a) Install sanitary pressure gage in tee at discharge of booster pump.

(b) Operate the pasteurizer with water, with the flow-diversion valve in forward-flow position, the metering pump operating at minimum speed possible, and the booster pump operating at its rated speed. If vacuum equipment be located between the raw outlet from the regenerator and the metering pump, it should be bypassed while this determination is made.

(c) Note maximum pressure indicated by pressure gage under these conditions.

2. Check and set the pressure switch.

(a) Install a sanitary pressure gage of known accuracy on the pneumatic testing device to which the pressure switch sensing element should also be connected.

(b) Remove the seal and cover to expose adjustment mechanism on pressure switch.

(c) Operate the testing device and determine the pressure gage reading at the cut-in point of the pressure switch which will light the test lamp. (If the switch be short circuited, the lamp will be lighted before air pressure is applied.)

(d) The cut-in point should be adjusted, if necessary, so as to occur at a pressure gage reading at least 1 pound per square inch greater than the maximum booster pump operating pressure, as determined under (1) preceding. Where adjustment is necessary, refer to manufacturer's instructions for adjusting procedure. After adjustment, recheck actuation point and readjust if necessary.

(e) Replace cover and seal the pressure switch and restore sensing element to original location.

(f) Record test results for the office record.

B. Time Delays Switches - Used to control operation of booster pumps.

Application. —To all time-delay switches controlling operation of booster pumps.

Frequency.—Upon installation, after any change in the pump or relay circuit and whenever seal is broken.

Criteria. — The booster pump shall not operate until the pasteurized milk has achieved a pressure at least 1 pound greater than the maximum pressure developed by the booster pump.

Apparatus. —Accurate stopwatch, graduated at intervals not to exceed 0.2 of 1 second, pressure gage or manometer.

Method.—Reference: Dashiell, W.N., Use of Time Delay Relay To Control Booster Pump Operation. Journal of Milk and Food Technology 21:7. July 1958.

Procedure.—(a) Operate pasteurizers with water with the flow-diversion valve in forward-flow position, metering pump operating at minimum speed, booster pump at rated speed.

Vacuum equipment not operating or bypassed.

(b) Determine the maximum pressure developed at the discharge of the booster pump. Following the determination of the height of the liquid level, add at least 3 feet to provide the 1-pound pressure differential equivalent of 0.7 feet of water column to compensate for difference in the specific gravity between water at 161° F. and raw milk at 40° F. The pasteurized liquid level must rise to the computed elevation, above the outlet level of the booster pump and be vented to the atmosphere at this or higher level.

(c) Time the interval from the moment the forward flow is established until the pasteurized liquid level rises to the required elevation. The time measurement shall be made at the beginning of a run when water is in the pasteurized product line. The booster pump shall not be operating.

(d) The time delay relay shall be installed in the circuit, interlocked with the metering pump, forward-flow of the flow-diversion valve and the booster pump. Adjust the time delay setting to provide the time interval. Check the setting several times. Seal the time delay relay.

(e) Record for permanent office record.

Corrective Action. —Adjust pasteurized milk pipe to proper elevation. If time delay relay be not accurate, return for repair.

C. Pressure Gages—Used with booster pump operations:

Application. —To all required pressure gages used to measure relative raw milk and pasteurized milk pressure in HTST regenerators.

Frequency.—Upon installation, each 3 months thereafter, and whenever the gages are adjusted or repaired.

Criteria.—Required pressure gages shall be accurate.

Apparatus. —Identical testing device used to check proper operation of pressure switch (Test 9).

A pressure gage of known accuracy is connected to one outlet of the test apparatus. The gage being checked is connected to the second outlet of the sanitary tee. Air is bled into the system through the third outlet and comparative readings made. Record test results for office record.

Corrective Action. —Inaccurate gages should be returned to the factory for repair. It is not recommended that the plant operator attempt the adjustment of pressure gages.

Test 10. Milk-Flow Controls - Milk Temperatures at Cut-in and Cut-out

References. —Item 16p (B), 16p (D).

Application. —To all recorder-controllers used in connection with continuous flow pasteurizers.

Frequency.—Upon installation and quarterly by the health authority; daily by the plant operator.

Criteria.—No forward flow unit pasteurization temperature has been reached. Flow diverted before temperature drops below minimum pasteurization temperature.

Apparatus. —No supplemental materials needed.

Method. —By observing the actual temperature of the indicating thermometer at the instant forward flow starts (cut-in) and stops (cut-out).

Procedure.—(a) Cut-in temperature.

(1) While milk or water is completely flooding the sensing element of the record-controller and the indicating thermometer, increase the heat gradually so as to raise the temperature of the water or milk at a rate not exceeding 1° F. every 30 seconds.

(2) Observe the indicating thermometer reading at the moment the forward flow starts (i. e., flow-diversion valve moves). Observe that the frequency pen reading is synchronized with the recording pen on the same reference arc.

(3) Record the indicating thermometer reading on the recorder chart; inscribe initials. The Health authority shall record test findings.

(b) Cut-out temperature.

(1) After the cut-in temperature has been determined and while the milk or water is above the cut-in temperature, allow the water to cool slowly at a rate not exceeding 1° F. per 30 seconds. Observe indicating thermometer reading at the instant forward flow stops.

(2) Record the indicating thermometer reading on the recorder chart.

Corrective Action. —Should the reading be below the minimum pasteurization temperature, the cut-in and cut-out mechanism and/or the differential temperature mechanism should be adjusted to obtain proper cut-in and cut-out temperatures by repeated tests. When compliance is achieved, seal the controller mechanism.

Test 11. Continuous Flow Holders - Holding Time

Reference. —Item 16p (B).

Application. —To all high-temperature short-time pasteurizers employing a holding time.

Frequency. —Upon installation and semiannually thereafter, whenever seal on speed setting is broken; any alteration is made affecting the holding time, the velocity of the flow (such as, replacement of pump, motor, belt, drive or driven pulleys, or decrease in number of HTST plates) or the capacity of holding tube; or whenever a check of the capacity indicates a speedup.

Criteria. —Every particle of milk shall be held for at least 15 seconds in both the forward and diverted flow positions.

Apparatus. —Electrical conductivity measuring device (1) capable of detecting change in conductivity, equipped with standard electrodes; table salt (sodium chloride), 50-ml. syringe; stopwatch; suitable container for salt solution.

Method. —The holding time is determined by timing the interval for an added trace substance to pass through the holder. Although the time interval of the fastest particle of milk is desired, the conductivity test is made with water. The results found with water are converted to the milk flow time by formulation since a pump may not deliver the same amount of milk as it does water.

Procedure. —(a) Examine the entire system to insure that all flow promoting equipment is operating at maximum capacity and all flow impeding equipment is so adjusted or bypassed as to provide the minimum of resistance to the flow. There shall be no leakage on the suction side of the timing pump.

(b) Adjust variable speed pump to its maximum capacity (preferably with a new belt and full size impellers). Check homogenizers for seals and/or gears or pulley identification.

(c) Install one electrode at the inlet to the holder and the other electrode in the holder outlet. Close the circuit to the electrode located at the inlet to the holder.

(d) Operate the pasteurizer using water at pasteurization temperature, with flow-diversion valve in forward flow position.

(e) Quickly inject 50 ml. of saturated sodium chloride solution into the holder inlet.

(f) Start the stopwatch with the first movement of the indicator of a change in conductivity. Open the circuit to the inlet electrode and close the circuit to the electrode at the outlet of the holder.

(g) Stop the stopwatch with the first movement of the indicator of a change in conductivity.

(h) Record results.

(i) Repeat the test six or more times, until six successive results are within 0.5 seconds of each other. The average of these six tests is the holding time for water in forward flow. When consistent readings cannot be obtained, purge the equipment, check instruments and connections, and check for air leakage on suction side. Repeat tests. Should consistent readings not be obtained, use the fastest time as the holding time for water.

(j) Repeat steps (d) through (i) for testing time on water in diverted flow.

(k) With the pump at the same speed and equipment adjusted as in (a) above, time the filling of a 10-gallon can with a measured weight of water using the discharge outlet with the same

head pressure as in normal operation. Average the time of several trials. (Since flow rates of the large capacity units make it very difficult to check by filling a 10-gallon can, it is suggested that a calibrated tank of considerable size be used.)

(l) Repeat procedure (k) using milk.

(m) Compute the holding time for milk from the following formula by weight, using the average specific gravity. Compute separately for forward flow and diverted flow.

Holding time for milk = $\frac{1.032\ (TMw)}{Ww}$ (by weight), in which -

1.032 = specific gravity for milk;
T = average holding time for water;
Mw = average time required to deliver a measured weight of milk.
Ww = average time required to deliver an equal weight of water.

(n) Record results for office record.

Corrective Action. —When the computed holding time for milk is less than that required either in forward flow or diverted flow, the speed of the timing pump shall be reduced or adjustment made in the holding tube, and the timing test repeated until satisfactory holding time is achieved. Should an orifice be used to correct the holding time in diverted flow, there should be no excessive pressure exerted on the underside of the valve seat of the flow—diversion valve. Governors shall be sealed on motors that do not provide a constant speed as provided in item 16p (B) 5b.

Chemical and Bacteriological Tests

Single-Service and Multiuse Pasteurized Milk and Milk Product Containers - Bacteriological

Application—To single-service and multiuse pasteurized milk and milk product containers.

Frequency—At least once each 3-month period.

Criteria—All multiuse containers shall be effectively subjected to an acceptable bactericidal process, producing containers having a residual bacterial count of not more than 1 per ml. of capacity or not over 50 colonies per 8 square inches (1 per square centimeter), in 3-out-of-4 samples and shall be free of coliform organisms.

All single-service containers shall have, just prior to use, a bacterial count of not more than 1 per ml. of capacity, or not more than 1 colony per square centimeter of surface area in 3-out-of-4 samples, and shall be free of coliform organisms.

Method —Bacteriological swab and/or rinse counts.

Apparatus and Procedure—See Standard Methods for Examination of Dairy Products for required swab and rinse counts.

Private Water Supplies and Recirculated Water - Bacteriological

Application— To private water supplies used by dairy farms, milk plants, receiving stations, and transfer stations, and to recirculated cooling water used in milk plants.

Frequency—Initially, and after repair, modification, or disinfection of private water supplies of dairy farms and milk plants and thereafter, semiannually for all milk plant water supplies. Recirculated cooling water in milk plants shall be tested semiannually.

Criteria—An MPN (Most Probable Number of coliform organisms) of less than 2.2/100 ml., or its membrane filter equivalent.

Apparatus, Method, and Procedure—See Standard Methods for Examination of Water and Wastewater.

Corrective Action—When the laboratory report on the sample is unsatisfactory, the water supply in question shall again be physically inspected and necessary corrections made until subsequent samples are bacteriologically satisfactory.

Pasteurization Efficiency - Field Phosphatase Test

Frequency—When any laboratory phosphatase test is positive, or any doubt arises as to the adequacy of pasteurization due to noncompliance with equipment, or standards.

Criteria—Less than 1 µg., per ml. by Scharer Rapid Method (or equivalent by other means).

See Standard Methods for the Examination of Dairy Products.

Method—The test is based on the detection of the phosphatase enzyme, a constituent that is inactivated by pasteurization at 145° F. for 30 minutes or 161° F. for 15 seconds. When pasteurization is faulty, some phosphatase remains and is detected through its action on phosphoricphenyl esters, releasing phenol, which is measured quantitatively by the addition of dibromo or dichloroquinonechlorimide to form an indophenol blue color.

Procedure—See Standard Methods for Examination of Dairy Products for details on phosphatase tests.

Corrective Action—Whenever a phosphatase test is positive, the cause shall be determined. Where the cause is improper pasteurization, it shall be corrected; and any milk or milk products involved shall not be offered for sale.

Phosphatase Reactivation in HTST Pasteurized Products

The presence of an appreciable quantity of phosphatase in milk and cream after heat treatment has been traditionally regarded as evidence of inadequate pasteurization. However, with the advent of modern high-temperature short-time methods, evidence has been accumulating that under certain conditions, the relationship between inadequate pasteurization and the presence of phosphatase does not hold.

A number of investigators who have studied high-temperature short-time pasteurizing methods have concluded that while a negative test can be obtained immediately after pasteurization, the same sample may yield a positive test after a short period of storage, particularly if the product be not continuously or adequately refrigerated.

This phenomenon has come to be known as reactivation.

Reactivation may occur in HTST pasteurized products after storage at temperatures as low as 50° F. although 93° F. is optimum. Products of high fat content generally produce relatively more reactivatable phosphatase.

Reactivation is greatest in products pasteurized at about 230° F. but may occur in products pasteurized at much higher temperatures and as low as 163° F.

It has been noted that an increase in holding time during pasteurization will reduce reactivation.

The addition of magnesium chloride to HTST processed milk or cream, after pasteurization but before storage, accelerates reactivation. The difference in activity between an adequately pasteurized sample stored with and without magnesium and an inadequately pasteurized sample stored with and without magnesium, forms the basis of a test for differentiating reactivated from residual (inadequately pasteurized) phosphatase. [1]

Detection of Antibiotics in Milk

The problem of antibiotics in milk is associated with their use in the treatment of mastitis and other diseases. Failure to withhold milk from the market for sufficient length of time after treatment is responsible for the presence of antibiotics in milk. Such milk is undesirable for two reasons; first, it originates in an unhealthy cow, and second, it is adulterated.

The allergenic properties of certain antibiotics in common use make their presence in milk potentially hazardous to consumers. Also, substantial losses of byproducts may be sustained by the milk industry each year because of the inhibitory effects of antibiotics on the culturing process.

Detection of Pesticides in Milk

Any health agency which has adopted this Ordinance should operate under a control program

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1. Campbell, J. E., and McFarren, E. F., Collaborative Test for Reactivated and Residual Phosphatase in Dairy Products. Journal of the Association of Official Agricultural Chemists, 44:3 August 1961.

which will insure that milk supplies are free from pesticide contamination, in conformance with Definitions R and R-1, Section 1, "Adulterated Milk and Milk Products" and "Misbranded Milk and Milk Products".

Pesticide compounds gain access to milk by various routes. Insecticide contamination may result from any of the following: (1) Application to the cows; (2) inhalation of toxic vapors by the animals following application of insecticides to their environment; (3) ingestion of residues in feed and water; and (4) accidental contamination of milk, feed, and utensils. Herbicide contamination may result from residues on the cows' feed and in their water supply; rodenticides may be present in milk as a result of accidental contamination.

At the present time, chlorinated hydrocarbon pesticides are the chief concern. While there are other pest control compounds which are more toxic than the chlorinated hydrocarbons, many of the agents in this latter group tend to accumulate in the body fat of both cows and human beings, and are secreted in the milk of contaminated cows. The accumulation of these toxic agents in persons continually consuming contaminated milk may reach hazardous concentrations.

Recent advances in residue analyses have resulted in a radical decrease in the use of paper chromatographic screening procedure for milk because of its rather limited sensitivity. Regulatory agencies can now routinely detect residues as low as 0.01 p.p.m. of many of the chlorinated organic pesticides. Satisfactory screening procedures should, therefore, attain this level of sensitivity which usually necessitates the use of gas chromatography or thin layer chromatography.

General screening procedures of the latter two types are described and discussed in Volume 1 of the Pesticide Analytical Manual published by the Federal Food and Drug Administration.

The need for closer scrutiny of milk supplies for pesticide residues has stimulated considerable research in detection technology.[2] The health authority entering upon a surveillance program should carefully check the available equipment in relation to its adaptability to the indicated need.

While a schedule of testing comparable to that for microorganisms (four tests of individual producers milk during any consecutive 6 months) would be desirable, broad spectrum procedures are too time consuming to render such a schedule feasible. As a more practical approach, the following procedure is suggested:

(1) Test one load of milk from each tank truck route every 6 months by a broad spectrum method, and trace positive samples, or

(2) Test each producer's milk four times every 6 months for the most common chlorinated hydrocarbon pesticides, by available instrumental methodology.

Note—The above testing disciplines may be applied conveniently to can milk supplies. Where plan (1) is used, samples of commingled milk from known sources are drawn from receiving station storage tanks. Sampling for plan (2) may be done directly from the weigh tank.

2. Schafer, M. L., Bush, K. A., and Campbell, J. E., Rapid Screening Method of DDT in Milk With Gas Chromatography. J. Dairy Science, 43:1025 (1963).

Tuberculosis and Brucellosis Eradication from Herds of Cattle

Tuberculosis Eradication

Uniform Methods and Rules for the Establishment and Maintenance of Tuberculosis-Free Accredited Herds of Cattle, Modified Accredited Areas and Areas Accredited Free of Bovine Tuberculosis in the Domestic Bovine, Adopted by the United States Livestock Sanitary Association on October 22, 1964, and approved by the Animal Disease Eradication Division effective December 17, 1964.

Part I: Definitions

1. "Accredited Herd" is one in which no reactors have been found on at least two consecutive annual tuberculin tests.

2. "Advanced tuberculosis" refers to carcasses of animals in which a lesion of tuberculosis (other than tuberculoid skin lesion) is found as a result of post-mortem examination.

3. "Annual tests" for purposes of herd accreditation means tests made within a period of not less than 11 nor more than 15 months.

4. An "Accredited establishment" is one at which supervised meat inspection is maintained at all hours when slaughter is in progress and post-mortem procedures meet recognized standards for the disclosure of lesions of tuberculosis and the procedures are adequate for maintaining the identity of individual cattle until inspection be completed.

5. A "Commercial dairy herd" is one composed of cattle of the recognized dairy breeds which produces milk that is marketed in any form for human consumption.

6. "Modified Accredited Area" is a State or portion thereof in which the degree of infection does not exceed one-half of one percent.

7. A "Registered purebred herd" is one that maintains a minimum of 10 registered purebred cattle throughout the year and from which registered animals may be sold for breeding purposes.

Part II: Individual Accredited Herd Plan

1. (a) Classification of animals tested
   (1) Reactors - "R"

Animals showing a P1 - X2 or greater response to the tuberculin on routine test should be classed as reactors unless in the professional judgment of the testing veterinarian a suspect classification be justified. In herds with known tuberculosis, all animals that respond to the tuberculin test will be classified as reactors.

(2) Suspects - "S"

This classification is to be used for animals showing any response at point of injection not classified as reactors, with the exception noted below.

(3) Negatives - "N"

Animals showing no tissue disturbance at site of injection will be classed as negatives. Animals showing a minimal tissue response (pp or x) in herds which contain no reactors on the current test, and in which bovine tuberculosis has not been demonstrated on previous tests may be classed as negatives.

Decisions will be based upon the professional judgment of the testing veterinarian in accordance with the policy established in a given area by the cooperating State and Federal officials.

(b) Herds in which reactors occur shall be quarantined and must pass a negative tuberculin test after a period of at least 60 days to be released from quarantine. If there be pathologic lesions considered bovine tuberculosis in one or more reactors or such lesions be found in non-reactors at slaughter in animals traceable directly to a herd, at least two negative tests at intervals of not less than 60 days will be required for release of quarantine.

(c) All herds in which bovine tuberculosis occurs shall be retested in approximately 12 months but not more than 15 months following the first negative test after disclosure of reactors. At this time, the herd may be accredited or reaccredited if it otherwise qualifies. These tests are to be followed by at least two annual herd tests.

(d) When suspects to the tuberculin test are disclosed in herds not containing reactors, such animals shall be immediately restricted to the premises. The accredited herd status shall be suspended, and no movement of animals from the herd permitted except under permit issued by the cooperating State authorities until the status of the herd be determined.

(e) Suspects may be sold by permit only for immediate slaughter at an accredited establishment or retained under restriction for a 60 to 120-day retest. If the suspects be removed for slaughter without retest, or not be slaughtered at an accredited establishment, the herd shall be retested in not less than two, nor more than six months from the date the suspects were disclosed.

(f) Tuberculin tests shall be applied by a veterinarian employed in a full-time capacity by the State, the Animal Disease Eradication Division, ARS, or by an accredited veterinarian. All tuberculin tests are official tests. A report of all tuberculin tests, including a record of all responses, shall be submitted in accordance with the requirements of the cooperating State and Federal authorities. These officials reserve the right to supervise any test conducted by an accredited veterinarian.

2. The official tuberculin test shall be the intradermal test. The intradermal injection of tuberculin in the cervical area is indicated for use only under the direct supervision of full-time employed State or Federal veterinarians in herds where advanced tuberculosis has been disclosed.

3. The entire herd, or any cattle in the herd, shall be tuberculin tested or retested at such times as are deemed advisable by the Cooperating State and Federal authorities.

4. No animal that has been designated as reactor at any time shall be retested.

5. (a) Reactors to the tuberculin test shall be removed from the herd in accordance with State and Federal laws and regulations. After their removal, the infected premises shall be thoroughly cleaned and disinfected with a disinfectant permitted by the Animal Disease Eradication Division, ARS, USDA, and in a manner satisfactory to the cooperating State and Federal authorities.

(b) A complete epidemiological survey shall be made on all herds in which reactors are disclosed, by appropriate State or Federal personnel.

6. Herd additions must originate directly from one of the following: (a) Tuberculosis-accredited herd. (b) An area accredited free of bovine tuberculosis in the domestic bovine. (c) A herd (not under quarantine) in modified accredited areas if the individual animals pass a negative test within 30 days of entering the premises.

7. To qualify for accredited herd status all animals must be bona fide members of the herd as attested by a certificate issued jointly by the local State and Federal officials. The

accredited herd status may be valid for not more than 1 year (365 days) from the date of the qualifying herd test. To qualify for reaccreditation the herd must pass a negative test within a period of 15 months from the last previous accreditation test.

8. Owners of accredited herds shall be required to maintain such environmental conditions as are consistent with the generally accepted standards of good sanitation and herd management. The use of milk or other dairy products for feeding is prohibited unless such products be from a known safe supply or have been pasteurized or sterilized. Identity shall be provided by eartag or other satisfactory means for all animals and complete records must be kept of all additions to the herd. Only properly cleaned and disinfected vehicles may be used for transporting cattle into accredited herds.

9. Failure on the part of an owner to comply with these methods and rules shall constitute sufficient cause for revocation of the accredited herd certificate.

Part III: Modified Accredited Area Plan

10. The provisions of the individual accredited herd plan that relate to testing, quarantine, removal of reactors, cleaning, disinfecting, sanitation, and epidemiology shall apply to the modified accredited area plan, except that in routine area testing all cattle twenty-four (24) months of age or over shall be tested. In herds with bovine tuberculosis all cattle shall be tested.

11. An area may be accredited or reaccredited for a period of six years provided that:

(a) All commercial dairy herds be tested.

(b) All registered purebred herds that are maintained under confinement at any period of the year be tested.

If a record be maintained indicating that an annual average of at least five percent of the cattle over two years of age in a herd have been slaughtered at accredited establishments and identified to the originating herd, such a herd record may be substituted for the testing required in (a) and (b). This substitution may be made if the record be continuous and has been in effect in excess of one year.

(c) All cattle in herds of origin or cattle associated with those showing evidence of tuberculosis at time of slaughter be immediately tested.

(d) All herds found with tuberculosis within the past 12 years be tested.

(e) Other cattle as may be considered necessary by the State and Federal cooperating officials be tested.

(f) The testing schedule of all reactor and suspect herds be current at the time of accreditation or reaccreditation.

(g) The total number of reactors found in the area on the last test of each herd during the reaccreditation period does not exceed 0.5 percent of the cattle tested.

12. An area may be reaccredited for a period of six years provided that:

(a) Reports be produced showing that during each year at least five percent of the cattle over two years of age in the area as determined by statistics of the ARS, or a total of 30 percent during the six-year period, have been subjected to a meat inspection examination at an accredited establishment and can be identified with the herd of origin.

(b) All cattle in herds of origin, or cattle associated with those showing evidence of tuberculosis at time of slaughter, be immediately tuberculin tested.

(c) All herds found with tuberculosis within the past 12 years be tested.

(d) Other cattle as may be considered necessary by the State and Federal cooperating officials be tested.

(e) The testing schedule of all reactor and suspect herds be current at the time of accreditation or reaccreditation.

(f) The total number of reactors found in the area on the last test of each herd during the reaccreditation period does not exceed 0.5 percent of the cattle tested.

Part IV: Accredited Tuberculosis Free Areas (Mycobacterium Bovis in Cattle)

A state, a county, or a block of several counties, which is part of a progressive plan for complete state coverage may be declared Accredited Tuberculosis Free (M. bovis in cattle) if the State complies with all the provisions of this part and no bovine tuberculosis has been found during the periods indicated.

13. (a) During the three-year period from effective date of this part, an area may be declared accredited Tuberculosis Free (M. bovis in cattle) if during two or more reaccreditation periods that cover at least twelve successive years, no Bovine Tuberculosis has been found.

(b) The cooperating State and Federal officials have declared an intent to qualify an area for free status and have records showing that during at least three successive years not less than 5% of the cattle over two years of age, or a total of 15% or more during the three year period have been identified from each individual herd to slaughter at an accredited establishment. All cattle 24 months of age or older in herds that do not meet this requirement shall be free of reactors to a tuberculin test applied within the qualifying three-year period.

or

(c) A state may qualify for free status if during a period of two successive years, 30 percent of the cattle population over two years of age have been identified from the state and slaughtered at accredited establishments.

or

(d) An area may qualify for free status if official records show that all cattle except as described in Paragraph 20-C in the area over two years of age, have had at least two successive tests covering a period of three but not more than six years, and no bovine tuberculosis has been found.

14. Any pathologic (granulomatous) lesion in cattle suspected of being tuberculosis will be considered bovine tuberculosis unless a satisfactory examination at an approved laboratory justifies a diagnosis other than bovine-type tuberculosis.

15. In the event that tuberculosis is disclosed or suspected, the provisions of the individual accredited herd plan that relate to testing, quarantine, removal of reactors, cleaning, disinfection, sanitation, and epidemiology shall apply.

16. All cattle in herds from which infected animals originate and cattle within the area that have associated with those found to be infected shall be promptly tested. Discovery of tuberculosis upon a premise shall be followed by a complete epidemiological investigation and every effort made to assure the immediate elimination of the disease from all species of domestic livestock and poultry.

17. State laws and/or regulations are in effect that provide for the testing of any animal or herd when deemed necessary by the State-Federal Cooperating officials.

18. Bovine tuberculosis found by Meat Inspection examination or otherwise in any bovine traceable to an Accredited Free area will be considered to have originated from that area unless satisfactory records be available to definitely show that the subject animal had originated from a specific place outside the Accredited Free area.

19. Dealer control laws or regulations that require the identification of cattle and records of transactions for each animal purchased and sold are enforced.

20. Cattle moved in channels of trade within a state having a free area shall be identified and recorded as to origin and destination at the first concentration point (dealer, livestock auction, stockyard, etc.,) as follows:

(a) Cattle that are returned to farms or ranches, including feeding cattle, shall be identified by permanent official ear tag or be branded cattle for intrastate movement only when accompanied by an official brand release.

(b) Cattle that are marketed for immediate slaughter shall be identified by permanent ear tag, sales tag, or official back tag. An official brand release will be acceptable identification for lots of animals of unmixed origin that are shipped directly to slaughter.

(c) Cattle without individual identification may be moved directly to and maintained in a quarantined feed-lot under control of the state livestock sanitary officials, provided they be inspected on the premises and be moved to slaughter to accredited establishments under permit at the end of the feeding period.

21. Cattle moved for purposes other than for immediate slaughter into areas accredited free of bovine tuberculosis in the domestic bovine or areas in the process of attaining this status shall meet one of the following requirements:

(a) Cattle properly identified and moved directly into the Free area from another Accredited Free area.

(b) Cattle properly identified and moved directly into the Free area from a tuberculosis-accredited herd.

(c) Cattle from a modified accredited area that are properly identified and moved directly from a herd not under quarantine and have individually passed a negative test within 30 days of entering the premises. The cooperating state and federal officials may waive the thirty (30) day test if the herd of origin has been actively covered by a screening procedure where during a three year period 15% of the cattle over two years of age have been identified from the individual herd through slaughter at an accredited establishment.

(d) Feeder cattle from a modified accredited area properly identified and recorded as to herd of origin and maintained under quarantine until slaughtered at an accredited establishment.

22. No animal that has reacted or is "suspicious" to a tuberculin test or is otherwise suspected of being infected with bovine tuberculosis shall be moved into an accredited free area for any purpose except as a direct shipment to slaughter accompanied by an official permit. Such animal movement must be subjected to the following conditions:

(a) Transported in vehicles with slaughter animals only.

(b) If unloaded in transit, they must use premises and facilities where only slaughter animals are accomodated.

(c) All vehicles and facilities unless used solely for slaughter animals must be cleaned and disinfected before being used again for other livestock.

23. All commercial slaughtering establishments in the area shall qualify as accredited establishments. However, establishments where not more than fifty thousand pounds of cattle (on a live-weight basis) are slaughtered in any calendar week may be exempt from this requirement.

24. Disclosure of extensive or spreading bovine tuberculosis in an accredited Tuberculosis free area and/or failure to take active steps to eliminate any tuberculosis found shall constitute sufficient causes for revocation of the accredited tuberculosis free status.

25. Unless an area be disqualified, it may maintain its status of Bovine Tuberculosis free in the Domestic Bovine for a period of six years provided (a) that during this six year period 5% of the cattle over two years of age or 30% over a six year period have been identified from each individual herd direct to an accredited establishment. All cattle 24 months of age or over in herds that do not meet this requirement shall be tuberculin tested within the requalifying six year period.

(b) A state may maintain its status of accredited tuberculosis free (M. bovis in cattle) for a period of six years provided that during the six year period a number equal of 90% of the cattle population over two years of age have been identified from the state through slaughter at an accredited establishment.

Bovine Brucellosis Eradication (Recommended Uniform Methods and Rules; U.S. Livestock Sanitary Association and Agricultural Research Service, United States Department of Agriculture.)

Part I: Definitions

A. "Positive" or "Reactor"

1) Official vaccinates, thirty months of age and over, or official vaccinates under thirty month of age that are parturient (springers) or post-parturient that disclose complete standard plate test or standard tube test agglutination reactions in the blood titer dilution of 1:200 or higher, or are positive to the brucellosis card test, or are found infected by other diagnostic procedures.

2) All other cattle more than six months of age that disclose a complete agglutination reaction in the blood titer dilution of 1:100 or higher, or are positive to the brucellosis card test, or are found infected by other diagnostic procedures.

B. "Suspect"

1) Official vaccinates, thirty months of age and over, or official vaccinates under thirty months of age that are parturient (springers) or post-parturient that disclose any agglutination in the blood titer dilution of 1:100 or incomplete in the 1:200 dilution.

2) All other cattle more than six months of age that disclose agglutination in the 1:50 dilution or incomplete agglutination in the 1:100 dilution.

C. "Negative"

1) Official vaccinates, thirty months of age and over, or official vaccinates under thirty months of age that are parturient (springers) or post-parturient that disclose reactions of not more than complete agglutination in the 1:50 dilution, or are negative to the brucellosis card test.

2) All other cattle more than six months of age that disclose a reaction of less than incomplete agglutination in the 1:50 dilution or are negative to the brucellosis card test.

D. The "Herd" Test

The herd test should include all cattle over six months of age except steers, spayed heifers, and official vaccinates under thirty months of age which are not parturient (springers) or post-parturient.

E. "Feed Lot" Cattle

A feed lot is a confined area where animals are maintained for finish feeding in a dry lot on concentrated feed with no facilities for pasturing or grazing.

F. "Market Cattle Test Animal"

Cattle moving in trade through auction markets, stockyards, or to slaughtering establishments, or those cattle assembled at farms or ranches which are being readied for immediate movement to markets, stockyards, or slaughtering establishments.

G. "Approved Brucella Vaccine"

A product that is approved by and produced under license of the United States Department of Agriculture to be used in the control of brucellosis through its injection into cattle.

H. "Official Vaccinate"

A female bovine animal vaccinated against brucellosis with an approved Brucella vaccine while three through eight months of age, or a female bovine animal of a beef breed vaccinated against brucellosis with an approved Brucella vaccine while from three through eleven months of age, under the supervision of a Federal or State Veterinary Official, permanently identified as a vaccinate and reported at the time of vaccination to the appropriate State or Federal agency cooperating in the eradication of brucellosis. When vaccination is performed, it should be done as soon after three months of age as possible to eliminate the problem of residual titers. (The Brucellosis Committee of the United States Livestock Sanitary Association has recommended that "beginning January 1, 1970, officially vaccinated heifers of the beef breeds be tested at 24 months of age, and those of the dairy breeds at 20 months of age.")

I. "Identification of Vaccinated Animals"

It is recommended that official vaccinates be tattoed or branded as follows:

1) The tattoo should be applied in the right ear and should be the U.S. Registered "shield and V". The "shield and V" should be preceded by a numeral indicating the quarter of the year, and followed by the last digit of the year in which the vaccination was done. For example, "1 + shield and V + 7" indicates the first quarter of calendar year 1967.

2) If the brand be used, it should be applied on the right jaw. The "V" should be applied in four different positions—one for each year over a four-year period—to indicate in which year the vaccination was done. The fifth year will repeat the first year, and so on indefinitely. In 1967 the "V" should be placed with the open end facing forward and so on clockwise indefinitely.

J. "Immediate Slaughter"

The delivery of animals to the slaughtering establishment within ten days from the date that the animals were either consigned for slaughter or a permit was issued for the consignment to slaughter. Such animals, upon delivery to the slaughtering establishment, shall be slaughtered as soon as practicable.

Part II: Recommended Procedures

A. Individual Herd Plans

1) Blood testing of herds, with permanent identification and prompt disposal of positives for immediate slaughter and optional vaccination of calves, and/or

2) Milk ring testing of dairy herds at intervals of three to six months with all suspicious herds handled according to the above paragraph (1). Note: Herds that have passed at least three successive negative milk ring tests at intervals of not less than three nor more than six months may be considered as having met the brucellosis requirements for Grade A milk production.

B. Participation on Area Basis

1) When seventy-five percent or more of the cattle owners representing at least fifty-one percent of the cattle in the area have placed their cattle under the individual herd plan by petitioning or other legal procedure, then the remaining owners shall likewise include their cattle in the program and the area will adopt the Modified Certified Area plan.

2) When at least ninety percent of the counties representing a majority of the cattle in the State have been legally designated as working toward Modified Certified Brucellosis Area status, the remaining herds and cattle in the State shall be placed under the Modified Certified Brucellosis Area plan.

C. Supervision

The official brucellosis eradication program shall be supervised by full-time employed State and/or Federal veterinarians.

D. Entering Premises

Persons engaged in the brucellosis eradication program shall be authorized to enter premises to carry out eradication procedures.

E. Services to Owner

Services to owner should be made available without expense to him so long as funds for such purposes are available (owner to provide for handling of his cattles). Provision should be made if possible to pay practicing veterinarians for brucellosis eradication services.

F. Classification of Animals

When the standard plate test or standard tube test is used, the following table shall be used in classifying the blood titers of tested animals:

Official Vaccinates				All Others			
1:50	1:100	1:200		1:50	1:100	1:200	
-	-	-	Negative	-	-	-	Negative
I	-	-	Negative	I	-	-	Suspect
+	-	-	Negative	+	-	-	Suspect
+	I	-	Suspect	+	I	-	Suspect
+	+	-	Suspect	+	+	-	Positive
+	+	I	Suspect	+	+	I	Positive
+	+	+	Positive	+	+	+	Positive

Card test results will be classified as either negative or positive.

G. Branding Positives

A permanent brand with the letter "B" (at least 2 x 2 inches) must be placed on the left jaw of all cattle classed positive. Positives must remain on premises where disclosed until a State or Federal permit has been obtained for movement to immediate slaughter where State approved inspection or Federal inspection is maintained.

H. Reports

All activities, conducted either privately or as a part of the official brucellosis eradication program, such as results of tests and vaccinations, must be reported promptly to State and Federal cooperating agencies.

Part III: Individual Certified Herd Plan

A herd under supervision may qualify as Certified Brucellosis-Free upon complying with the following provisions of the State-Federal Cooperative Brucellosis Eradication Program:

Section I. Herd Certification

A. Herd Blood Tests: Herd blood tests shall be conducted at intervals of not more than sixty days until all evidence of infection has been eliminated. A herd may be certified as brucellosis-free when it has passed at least two consecutive negative blood tests, with the first clean test and the certifying test not less than twelve months nor more than eighteen months apart. Additional herd tests may be conducted on herds if the owner so desires, or if the certifying agencies deem it advisable.

B. Herd Retests: If there be no evidence of infection on the first blood tests, a herd may be certified as brucellosis-free when it has passed one additional negative test conducted not earlier than six months nor more than eighteen months from the date of the first test.

C. Utilizing the Milk Ring Test: When the milk ring test is employed, herds may be initially certified as brucellosis-free with a minimum of three negative milk ring tests conducted at not less than ninety-day intervals and followed by a negative herd blood test conducted within ninety days after the last negative milk ring test. Herds in which infection has been disclosed shall be tested in accordance with the provisions of paragraph A of this section.

Section II. Herd Recertification

A. Negative Herds: Upon evidence of a negative herd blood test at the end of one year, the herd may be recertified for one year. If the herd recertification test not be accomplished before the anniversary date, it may be reinstated if the certification test not be delayed more than three months beyond the anniversary date. In these cases, the recertification period will be twelve months from the anniversary date and not twelve months from the date of the recertifying test.

B. Herds with One Reactor: If the retest of a certified herd or of animals from such a

herd reveals one reactor, the certified status will be suspended. The herd may be recertified on the result of a negative herd retest conducted not earlier than sixty days following removal of the reactor. Intervening blood tests, if any, must be negative or the certification will be removed.

C. Herds with More Than One Reactor: If the retest of a certified herd or of animals from such a herd reveals more than one reactor, the herd certification will be removed and the herd may be requalified according to Section II, paragraph A, of this part.

D. Herds with Suspects: If the retest of a certified herd discloses suspects but no positives, only the suspicious animals need to be retested. If all suspects be available for retest and be negative, the herd test may then be considered negative. If the retest does not include all suspicious animals, or if one or more positive results, the herd should be retested as provided in Section II, paragraph B or C, of this Part. If only one suspect be not available for retesting and if that suspect be an official vaccinate, the herd test will be considered negative and the herd will be recertified, providing other requirements be complied with.

Section III. General Provisions

A. Official Vaccinates: Official vaccinates under thirty months of age, other than those which are parturient (springers) or post-parturient, are not required to be tested, or, if tested, are not required to be negative. All other official vaccinates classed suspect may be retained in isolation for retesting until their status be determined.

B. Herd Additions: Additions to certified herds or herds with negative tests shall be limited to the following:

1) To certified herds:
   a) Natural herd increase.
   b) From herds with equal status.
   c) From herds that have passed a negative blood test within the past twelve months:
      1) Official vaccinates under thirty months of age, other than those which are parturient (springers) or post-parturient, on certificate of vaccination; all other official vaccinates if negative within thirty days prior to addition.
      2) All other cattle on evidence of negative retest not less than sixty days from date of negative herd test.
2) To herds that have passed a negative blood test within the past twelve months:
   a) Natural herd increase.
   b) From herds with equal or superior status.
   c) From other herds:
      1) Official vaccinates under thirty months of age,other than those which are parturient (springers) or post-parturient, on certificate of vaccination; all other official vaccinates if negative within thirty days prior to addition.
      2) All other cattle if tested negative within thirty days prior to addition, then segregated and retested negative in not less than sixty days from date of first test.

C. Status of Herd Additions: Animals qualifying as additions under subparagraphs (1) (c) and (2) (c) of paragraph B, this Section, shall not receive new herd status for sale purpose until they have been members at least thirty days and are included in a complete herd retest.

D. Certificates: Certified Brucellosis-Free certificates which shall be valid for one year unless revoked, may be issued by cooperating State-Federal officials.

E. Quarantine: The entire herd must be confined to the premises if reactors be disclosed by the blood test. Movement of all cattle should be prohibited until the herd has passed a negative herd retest at least sixty days following removal of reactors, except cattle consigned for immediate slaughter under permit. It is recommended that herd blood tests be conducted at intervals of thirty days.

F. Cleaning and Disinfection: Premises shall be cleaned and disinfected under regulatory supervision within fifteen days following removal of reactors. An extension of time may be considered under extenuating circumstances. Exclusion of the cleaning and disinfection requirements are at the discretion of the cooperating officials directing program activities in the State.

Part IV: Modified Certified Brucellosis Area Plan

The provisions of the individual certified herd plan that relate to quarantining, cleaning, and disinfection should apply to the Modified Certified Brucellosis Area plan. The extent of the area shall be determined by the cooperating State and Federal agencies. All tests for area certification should be performed within an eighteen-month period.

Section I. Area Certification

A. Initial Modified Area Certification: During an eighteen-month period immediately preceding a request for certification, all cattle and herds will be accounted for by one or more of the following:

1. Complete herd negative blood test of all eligible cattle.

2. At least three successive negative milk ring tests over a period of the last eighteen months. Qualifying tests will be conducted at approximately equal intervals.

3. Blood tests of randomly selected eligible cattle in a herd, the number selected to be in accordance with graph in Figure 1.

4. Market cattle tests of fifteen percent of all eligible cattle over three years of age, from a given herd over an eighteen month period. When reactors are disclosed, the herd of origin of each reactor will be tested or accounted for and the results of those herds tested will be included in the request for certification.

B. Qualifying Standards: 1. If the infection rate in the area does not exceed one percent of the cattle and the herd infection rate does not exceed five percent, the area may be declared a Modified Certified Brucellosis Area for a period of three years. Infected herds shall be quarantined until they have passed one negative blood test at least sixty days following removal of the cattle classed positive, except cattle consigned for immediate slaughter under permit. All milk ring test suspicious herds must qualify by a negative blood test. All States are encouraged to require thirty-day retests while infection exists in these herds.

2. When computing the infection rate, herds which do not meet the testing requirements as outlined in Section I, paragraph A, must be quarantined, and all the animals in these herds counted as reactors.

C. Infection Rates: If testing as outlined under this section reveals an animal infection rate of more than one percent but not over two percent, and/or a herd infection rate of more than five percent, and an initial retest of a sufficient number of the infected herds applied not less than sixty nor more than one-hundred twenty days following removal of the cattle classed positive reduces infection rates to not more than one percent animal infection and not over five percent herd infection, the area may be certified. All infected herds shall be quarantined until the entire herd has passed one negative blood test not less than sixty days following removal of the cattle classed positive, except cattle consigned for immediate slaughter under permit.

D. Complete Area Retest: If the results of the tests conducted as outlined in this Section result in more than two percent positives, or if an initial retest of infected herds as under paragraph B, subparagraph 3, of this Section does not qualify the area for certification, it shall be necessary to make a complete area retest in accordance with paragraph A of this Section.

E. Feeding Bulls and Cows on Quarantined Premises: Bulls and female cattle being held under quarantine for feeding purposes, separate and apart from dairy or breeding cattle,

may be exempted from test provided such cattle be sold for immediate slaughter under permit from the appropriate State Livestock Sanitary Official at the end of the feeding period.

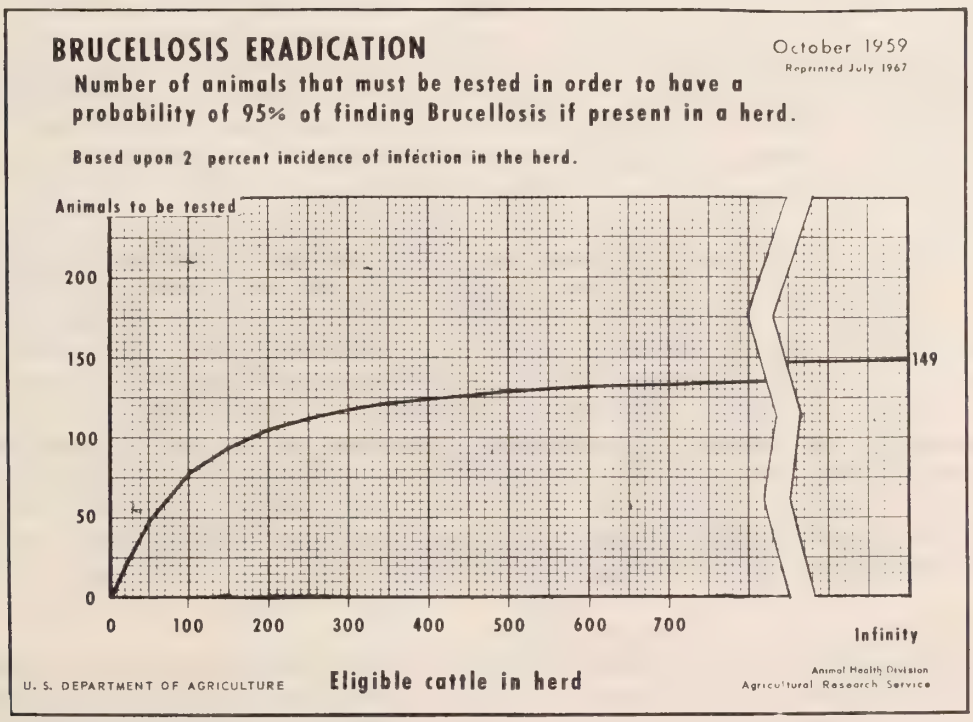
Section II. Modified Area Recertification

At the expiration of the three-year period, areas certified under Section I may be recertified for another three-year period by one or more of the following procedures:

A. Methods: 1. Herd Blood Tests

Blood tests of at least twenty percent of the representative herds in the area. A different twenty percent will be selected for each recertification. A complete herd blood test of all eligible cattle or a blood test of a representative sample as determined by graph in Figure 1 will be acceptable procedure. In addition, a herd blood test will be required on all herds known to have been infected during the previous certifying test.

Figure 1.



2. Milk Ring Tests

At least semiannual milk ring tests of all dairy herds with a herd blood test of all herds suspicious to the Brucellosis Ring Test (BRT).

3. Market Cattle Testing

Market Cattle Testing (MCT) of at least five percent a year during a three-year period for a total of at least fifteen percent of the breeding cows in the area in herds not covered by a ring test.

a. MCT reactors will be traced to herds of origin and herds suspected of being affected will be tested.

b. When less than fifteen percent of the breeding cows in non-BRT herds in the area are reported under Market Cattle Testing over the three-year period, additional testing will be required. This testing must include at least twenty percent of the herds in the area not accounted for by BRT or MCT. The herds tested should be of average size.

c. In those areas where Market Cattle Testing has been initiated during the recertification period and can be demonstrated as being on a continuous basis, consideration may be

given to prorating the MCT data accumulated when the percent coverage is less than the minimum stated requirements.

4. All purebred herds in the area must be included in one or more of the preceding requirements.

5. Bulls and female cattle being held under quarantine for feeding purposes, separate and apart from dairy or breeding cattle, may be exempted from test requirement provided such cattle be sold for immediate slaughter under permit issued by the appropriate State Livestock Sanitary Official at the end of the feeding period.

B. Infection Rates: Requirements pertaining to infection rates permitted for modified certification of areas are identical to those established for initial modified area certification.

C. Complete Area Retest: Any area not qualifying for recertification under the provisions of Section II of this Part shall be required to reestablish its certified status through testing procedures outlined in Section I of this Part, unless it can be qualified within six months of the due date in which case it may be reinstated.

Section III. Additions to Modified Certified Brucellosis Areas

A. Cattle from Certified Herds or Areas: Cattle from officially Certified Brucellosis-Free Herds or Areas and cattle from herds not known to be affected in Modified Certified Brucellosis Areas may enter Modified Certified Brucellosis Areas without being retested for brucellosis. All such cattle shall be individually identified.

B. Cattle from Non-Certified Areas: 1. Individual Cattle from Untested Herds

All cattle over six months of age, including official vaccinates over thirty months of age and those under thirty months of age which are parturient (springers) or post-parturient, except steers, spayed heifers, and cattle intended for immediate slaughter, shall be required to pass a negative officially recognized blood agglutination test for brucellosis within thirty days prior to the date of entry. They shall be allowed entry only under permit from the State of destination and be maintained in quarantine separate and apart from all other cattle and be retested negative in not less than thirty nor more than ninety days after date of entry. Should reactors be found in cattle held in isolation for retest, they shall be consigned for immediate slaughter and all exposed cattle shall be continued in isolation until they have passed a negative test not less than sixty days following removal of reactors.

2. Individual Cattle From Tested Herds

Cattle included in the several categories in the above paragraph (1) having originated in herds that are negative to a herd blood test within ninety days prior to movement and the individuals being considered for movement retested negative at least thirty days from the date of the previous herd test and within thirty days prior to movement may be permitted entry into a modified certified area without further restriction.

Part V: Certified Brucellosis-Free Area Plan

Areas may qualify as Certified Brucellosis-Free for a period of six years.

Section I. Establishing Certified Brucellosis-Free Areas

A. Methods for Initial Free Certification: Areas may qualify as Certified Brucellosis-Free provided that:

1. They be located in a State in which all other areas are at least currently Modified Certified Brucellosis Areas.

2. They have qualified on the basis of one or more of the following procedures applied within not more than twenty-four months nor less than eighteen months immediately preceding the request for Certified Brucellosis-Free status:

a. The milk ring test shall be conducted at least three times a year. Each qualifying herd shall have a minimum of at least four consecutive negative tests.

b. Market cattle testing in which the equivalent of five percent of the breeding cows in each non-BRT herd are blood tested each year. All reactors will be traced to herds of origin and the herd blood tested.

c. Market cattle testing in which the equivalent of ten percent of the breeding cows in non-BRT herds in the area are tested each year. A minimum of ninety percent of the reactors will be traced and the herds of origin will be blood tested.

d. Complete herd blood test of the eligible cattle in each herd.

e. Blood test of a representative sample of the herd in accordance with the number indicated in graph in Figure 1.

In addition:

3. a. All suspects to the blood agglutination test shall be slaughtered or retested sufficiently to determine a negative status. If the suspects be not available for retest, the herds having had suspects shall be retested or qualify under the provisions given for MCT or BRT in this Part.

b. A system employing positive identification of all slaughter cows and bulls over thirty months of age, whether of beef or dairy breeds, moving in intrastate and interstate commerce, shall have been initiated in the area.

c. All herds of other species of domestic livestock in which brucellosis has been found or suspected have either been tested negative or eliminated, leaving no known foci of infection.

B. Qualifying Standards: 1. Infection Rates: a. Not more than one percent of the herds or one herd, whichever is greater, shall have been found to be infected during the twenty-four months immediately preceding the request for Certified Brucellosis-Free Area status.

b. Not more than two-tenths of one percent of the cattle shall have been found to be infected during the twenty-four months immediately preceding the request for Certified Brucellosis-Free Area status.

c. If all the eligible herds not be adequately screened during the qualifying eighteen months, data may be accumulated for a total of twenty-four months.

2. Other Requirements: a. All herds in which brucellosis has been known to exist shall have been legally released from quarantine following a negative retest not less than sixty days after removal of all reactor animals.

b. All herds in which brucellosis has been found during the latest certification period shall have been retested not less than three months following removal of the last reactors or be qualified under the provisions given for MCT or BRT in this part.

3. Evidence shall be available to determine that there is a concerted effort being made, through effective screening programs and extensive epidemiology, to locate any infection and to eradicate the disease.

4. The provisions of the individual certified herd plan that relates to quarantining, cleaning, and disinfection shall apply to Certified Brucellosis-Free areas.

5. The official tube agglutination test or the card test shall be utilized in all blood serum agglutination tests conducted in relation to establishing and maintaining Certified Brucellosis-Free Areas, except that screening of samples at 1:25 using the standard plate agglutination test will be permitted.

6. Animals classed as reactors must be immediately marketed for slaughter. If they be marketed within a Certified Brucellosis-Free Area, they should be transported directly to the holding pens of a slaughtering establishment. They are not to be unloaded on to any premises or facilities, within the defined area, which are used for holding or handling livestock for purposes other than direct slaughter.

7. Calves under six months of age, steers, and spayed heifers are exempt from test requirements. Beef-type cattle may be maintained for purposes of dry lot feeding in Certified Brucellosis-Free Areas seeking such status, provided they be quarantined on the premises, subject to periodic inspection, and be moved to slaughter under permit at the end of the feeding period.

Section II. Maintaining Certified Brucellosis-Free Areas

A. Methods for Recertification of Brucellosis-Free Areas: 1. All conditions as stated in the requirements for establishing initial Certified Brucellosis-Free Area status shall apply in the recertification requirements, including the qualifying standards.

2. If the percentage of infected herds exceeds the limit set forth for initial Certified Brucellosis-Free status, the area shall revert to a Modified Certified Brucellosis Area and must requalify in accordance with the requirements for initial certification of a brucellosis-free area.

Section III. Additions to Certified Brucellosis-Free Areas

A. Cattle from Certified Herds and Areas: Cattle from officially certified brucellosis-free herds or areas may enter brucellosis-free areas without tests. Cattle from herds not known to be infected from modified certified areas may be permitted entrance into Certified Brucellosis-Free Areas if they be negative to a blood test within thirty days prior to entry. This test requirement may be waived if the herd has been maintained under an active screen testing procedure.

B. All Other Cattle: Animals not qualifying under paragraph A may enter a Certified Brucellosis-Free Area provided they have been held in isolation on premises in which brucellosis is not known to exist, and have, while in isolation, passed two negative blood tests, not less than thirty days apart, the second to be within thirty days of entering the area. Should any reactors be disclosed in a group of cattle held in isolation under this paragraph, none of the animals in the group will be eligible for entry into a Certified Brucellosis-Free Area, regardless of individual animal tests.

C. Exemptions: The following classes of cattle are exempt from these requirements, provided they originate from herds not known to be affected:

Steers, spayed heifers, calves under six months of age, and official vaccinates under thirty months of age, unless parturient or postparturient.

D. Slaughter Cattle: Animals not known to be affected with brucellosis and those known to be reactors to the test may be consigned to slaughter at establishments within a Certified Brucellosis-Free Area, provided they be transported directly to holding pens at the slaughter establishment and are not unloaded onto premises or into facilities utilized for holding or handling livestock for any other purposes than consignment for slaughter.

Bovine Mastitis Control Program

Step I. Identification of Dairy Animals for Herd Improvement

Positive identification of every dairy animal is necessary for maximum herd improvement. The dairyman can do a better job in feeding, breeding, disease control, record keeping and managing his herd if each animal be identified as to sire and dam with a permanent number. Bulls used in the animal identification program can be proved more quickly and completely and the problem of breeding a bull back to his daughters can be eliminated. The more a dairyman knows about individual cows the greater interest he will have in them and the better job he will do in managing his herd.

Method of Identification

Acceptable identification shall be the registration number for registered cows and the standard ear tag for grade cows. Tattoo numbers, neck tags, pictures, diagrams, or individual calf pens (with identification) may be used for temporary identification until the calf be registered or tagged with a permanent ear tag number. In order for the program to be of value, the information on the properly identified animal must be recorded and maintained as a permanent record. The registration certificate serves this purpose for registered cows.

Adult animals not previously identified should be identified by way of neck chains or permanent ear tags and this information recorded on permanent records.

Step II. Equipment Checks

Proper operating equipment is a must for mastitis control. Equipment must be thoroughly

checked to insure proper operation. It is recommended that this check be run at least twice a year.

Step III. Milking Procedure Checklist

Poor milking procedures can result in injury to the udder and mastitis even with the best operating equipment. The following are recommended milking procedures:

Managed Milking Procedure

1. Prepare the Cow for the Milking Operation. Prior to milking the udder, rear legs and front feet of each cow should be washed. Clipping of the udder, rear legs and flanks makes this job easier. The cow should be observed for cuts, bruises or other abnormalities.

2. Prepare the Udder for Milking. Single-service paper towels should be used. Towels, before use, should be immersed in a sanitizer solution, preferably an Iodophor[1] solution. After washing is completed, the udder should be dried with a second towel. The massaging action on the udder will stimulate "let-down". Check each quarter of the cow by feeling of the quarter. This will aid in the detection of feverish and hard areas in the quarter.

3. Use a Strip Cup or Plate. Remove a few streams of milk from each quarter in a strip cup or plate about a minute before attaching the machine. The Strip Cup Test is conducted by milking a few squirts of foremilk from each teat through a fine screen or by allowing the milk to flow over a black surface. Strip cups can be purchased with either a fine screen or black surface incorporated into the cover. Abnormal milk, characterized by visible flakes or clots, is easily detected. Moreover, milk that is unusually thick or thin and watery, but which does not contain clots, may be detected also. Many dairy farmers feel that the use of the strip cup at each milking will slow down the milking operation. This is not the case because the use of the strip cup will tend to speed up milking by stimulating milk let-down. Another important reason for using the strip cup on every cow at each milking is that it will lower the bacteria count because the first streams contain the largest number of bacteria.

4. Attach Milking Machine at Proper Time. Within 40-60 seconds after udder preparation, most cows will begin to "let-down" their milk. Apply machine gently after cow has "let-down" her milk.

5. Operate the Milking Machine Properly. Research work has shown that dairymen using milking machines properly have the best success in the control of mastitis. The incidence of mastitis is lower when the machine is equipped with rubber parts that are clean and in good repair, and when the manufacturer's instructions as to inches of vacuum and rate of pulsations are followed closely. Maintain two sets of rubber goods and alternate them weekly.

6. Machine Strip. The majority of cows will milk out within 3 to 6 minutes. Each teat should be machine stripped when it is nearly collapsed and before milk flow has stopped (as shown by the appearance and feel of the udder). This is done by pulling down gently on the teat cups and massaging each quarter with a gently downward motion. As a quarter is milked out, the teat cup should be removed even though other quarters be not completely milked out. Remove machine promptly when milk flow ceases. Continuous machine action after the milk flow stops may cause udder injury. This is one of the chief factors contributing to mastitis. If the teat cups are allowed to crawl up on the udder, the delicate lining of the teat cistern may be injured. This allows a free passageway for bacteria to attack the udder tissue. Remove teat cups gently by shutting off the vacuum, then pressing the thumb between liner and the teat. This breaks the vacuum seal so that the teat cup will fall off.

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1. Iodophors are sold in liquid form and should be used in solutions of 25 to 50 ppm. of available Iodine. Make new solutions when color disappears. If either of the preparations causes irritation or chapping of teats, reduce the strength of the solution. Follow instructions on label of preparation used. Chlorine is available in liquid or powder form in several different concentrations and should be used in solutions of 200 to 250 parts per million.

7. Dip Teats in Clean Disinfectant Solution. Teats should be dipped in a clean Iodophor solution of proper strength after removal of machines. Allow the teats to air dry. (This helps prevent pox and most staphylococcus mastitis.)

8. Disinfect Teat Cups Between Cows. Rinse the milking machine teat cups between milking of cows, first in clear lukewarm water, then in a fresh, warm Iodophor or Chlorine solution. Change the disinfectant as needed during the milking operation to keep its germ-killing power at a high level. Be sure the solution gets up into the inflations. Teat cup washers generally do a more effective job of cleaning than hand dipping of teat cups. Clean inflations help prevent spread of mastitis. These solutions are effective on clean surfaces, and ineffective on dirty surfaces.

Step IV. Laboratory Screening Tests on Bulk Tank Milk

The leucocyte count of bulk herd milk is an indication of the amount of mastitis present in a dairy herd. The number of leucocytes (white blood cells) in milk is not only a measure of udder health, but is a measure of milk quality as well. Such milk contains less than the permissible limit of one million leucocytes per milliliter of milk.

Step V. CMT (California Mastitis Test) or Similar Paddle Test on Individual Cows at Monthly Intervals

Dairy farmers who want to control mastitis in their dairy herd should conduct the California Mastitis Test (CMT) on their cows at monthly intervals. The CMT detects leucocytes which are present in milk in large numbers when the quarter is infected with mastitis-producing bacteria or when the tender milk-producing tissue of the udder has been injured.

The CMT is performed by using a white plastic paddle with four shallow cups and a prepared test solution. A small amount of milk from each quarter is drawn into the proper cup and the paddle is tipped to a near vertical position. The amount of milk remaining in the cups (2-3 ml) is sufficient for the test. The paddle is tipped forward and the test solution added in equal quantity to the milk in each cup. The test solution and milk are mixed by a circular movement of the paddle in a horizontal plane. Reactions occur during the movement that can be observed and scored. A gel is formed in the presence of leucocytes and the consistency of the gel is in proportion to the number of leucocytes present in the milk. The paddle is made ready for another cow simply by emptying the contents and rinsing in tap water. It is important to read test as soon as completed.

When used regularly, the CMT can be a valuable aid in detecting and controlling mastitis since it focuses attention on individual quarters that are secreting milk which contains an unusually high number of leucocytes. It is particularly useful in detecting chronic or subclinical mastitis that, heretofore, has often gone unnoticed until it has progressed to an advanced stage.

Some experience is necessary to interpret properly the CMT reactions because high reactions may not necessarily indicate that mastitis-producing bacteria are present in the quarter. For instance, high CMT reactions may be observed if the cow involved be either in very early or very late lactation. Similar reactions may be obtained when the tender udder tissue has been injured by misuse or malfunctioning milking equipment.

When an increasing number of high CMT reactions are observed, the dairy farmer should re-examine his milking procedure and have his milking equipment checked with specially designed testing equipment. If the situation does not improve following the introduction of better milking practices, the local veterinarian or dairy plant fieldman should be contacted and milk samples should be taken for bacteriologic studies in the laboratory. The CMT should never be used as the sole basis for making decisions relative to mastitis.

The CMT should be conducted on milk from all lactating quarters at least once each month. The test results should be recorded on individual records for each cow so that the CMT history of a cow can be seen at a glance.

Test solutions can be purchased commercially for conducting the CMT. However, test

solutions can be easily prepared by the dairyman by diluting 2.5 level teaspoons of high test lye and 4 level teaspoons of Swan liquid detergent in 1 gallon of soft tap water. After gentle mixing to dissolve the lye, the solution should be allowed to stand for 24 hours to permit it to clear. The clear portion is poured into a clean container and any settle-out impurities are discarded. One level teaspoon of Rit Tints and Dyes (Navy Blue No. 30) is added to the clear test solution to produce the desired color and the solution will be ready for use.

Traditional CMT Grading System

(Some dairy farmers may prefer to use the simplified grading system presented below rather than this traditional grading system.)

CMT Symbol	Suggested Meaning	Description of visible reactions	Interpretation
-	Negative	The mixture remains liquid with no evidence of formation of a precipitate.	0-200,000 cells per milliliter.
1	Weak positive	A distinct precipitate forms but there is no tendency toward gel formation. With some milks the reaction is reversible, for with continued movement of the paddle the precipitate may disappear.	400,000-1,500,000 leucocytes per milliliter.
2	Distinct positive	The mixture thickens immediately with some clump (gel) formation. As the mixture is caused to swirl, it tends to move in toward the center, leaving the bottom of the outer edges of the cup exposed. When the motion is stopped, the mixture levels out again and covers the bottom of the cup.	800,000-5,000,000 leucocytes per milliliter.
3	Strong positive	A gel is formed which causes the surface of the mixture to become convex (rounded). Usually there is a central peak which remains projecting above the main mass after the motion of the paddle has been stopped. Viscosity is greatly increased so that there is a tendency for the mass to adhere to the bottom of the cup.	Leucocytes number generally over 5,000,000 per milliliter.

Simplified CMT Grading System

CMT Symbol	Suggested Meaning	Description of visible reactions	Interpretation
-	Negative	The mixture remains liquid and any precipitate which forms will decrease in intensity or completely disappear with continued swirling of the paddle.	Less than 1,000,000 leucocytes per milliliter.
+	Positive	The mixture thickens immediately with a heavy, thick gel formation. The reaction does not disappear with continued rotation of the paddle.	More than 1,000,000 leucocytes per milliliter.

Note: The CMT can be conducted for less than one cent per cow per month. Test kits are inexpensive and can be obtained from producer associations, milk plants, veterinarians, etc.

Step VI. Laboratory Examination of Milk Samples from CMT Positive Quarters as Shown in Step V.

Bacterial culture examination of infected quarters should be a must before attempting treatment. Without the knowledge of bacteria present, it is difficult to recommend the proper treatment.

Cultural Examination

1. Veterinary examination of individual cows including udder palpation.

2. Sterile individual quarter samples should be collected by or under the supervision of a veterinarian and properly refrigerated until delivery to a laboratory.

3. The samples should be incubated in the laboratory and pathogenic organisms identified by appropriate tests.

4. Sensitivity testing of a representative number of samples as recommended by the attending veterinarian.

5. Attending veterinarian interprets the results of laboratory tests and makes recommendation for treatment and control.

6. Additional tests at 2-4 week intervals on quarters considered suspicious or positive, as recommended by the attending veterinarian for most effectively bringing the condition under control.

Step VII. Follow a Complete Herd Health Program Under the Guidance of a Veterinarian

A complete Herd Health Program is necessary in order to have an effective mastitis control program. Prevention is the way to control mastitis. This begins with baby calves and they should not be allowed to suck each other. Treatment normally should be the last step in mastitis control.

Vaccination

Vaccination against mastitis has not proven successful as a routine procedure in a large number of herds. In some problem herds, it has been thought helpful. Immunization procedures against mastitis in individual herds should be on recommendation of the attending veterinarian.

Treatment

1. Treatment should be selected by the attending veterinarian and applied as directed by him. Therapy during the dry period is more effective and is recommended; however, the acute cases of mastitis should be treated immediately. Milk should be discarded from treated quarters as recommended by the manufacturer of the therapeutic preparation.

2. Cows with udder injury should be considered as potential mastitis cases and so managed.

Abnormal Milk Program* (See Item 1r. PHS 1965 Milk Ordinance)

All segments of the dairy industry should adopt and support a uniform program for the control of abnormal milk. The dairy industry and the milk regulatory authority are jointly responsible and should use all available resources and techniques to eliminate abnormal milk from their milk supply.

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*Journal of Milk and Food Technology, July 1967, Vol. 30, No. 7, pp. 210-211.

Indicator tests for the detection of excessive number of leucocytes in milk are recommended as an adjunct to already existing tests to provide the consumer with a safe, high quality product consistent with the production of wholesome dairy products. Uniform screening programs for the detection of leucocytes are needed.

The National Mastitis Council, Inc., states that the presence of more than 500,000 leucocytes per ml.of mixed herd milk strongly suggests a significant incidence of mastitis in a given herd. Colostrum milk, mastitis, udder injury, stripper milk, and diseased cows are some of the common causes of high leucocyte counts. The Council recognizes that current knowledge cannot be expected to either eradicate or completely control bovine mastitis, but that the standard of not more than 1,500,000 leucocytes per ml.on herd milk is attainable by the application of known, control procedures which will effectively exclude from supplies that milk produced under conditions which disregard prevention and control procedures.

The Council feels that a program for the control of abnormal milk should be implemented by successive steps, as follows:

Phase I - Effective July 1, 1967. Laboratory examinations or screening procedures for the presence of unwholesome, altered mammary secretions, whether of an inflammatory, infectious, physiological, or environmental origin, in raw milk for pasteurization shall be made at the same frequency as specified for bacteriological tests. The milk producer shall be notified of all test results. The official indicator tests shall be conducted by an approved laboratory utilizing the official indicating tests, for the detection of abnormal milk.

Phase II - Effective July 1, 1968. Only those interstate milk shippers that are certified to be following an indicating test program shall be listed in the quarterly publication, "Sanitary Compliance and Enforcement Ratings of Interstate Milk Shippers". It is recommended that the U.S. Public Health Service adopt official laboratory indicating test(s) for the detection of abnormal milk and that test(s) be published by the U.S. Public Health Service and subjected to the State Laboratory Certification Program. After this date, when a herd milk sample tested by an approved laboratory indicates the presence of 1,500,000 or more leucocytes per ml, the following procedure shall be followed:

a. A warning letter shall be sent to the producer notifying him of the high leucocyte count. The letter shall also list the principal causes of excess leucocytes count.

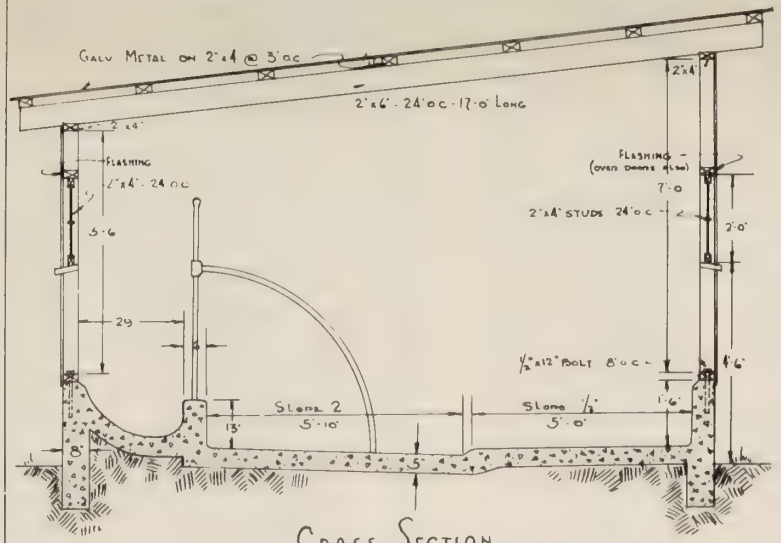
b. Following the second consecutive indicating test indicating a raw milk count of 1,500,000 or more leucocytes per ml, an inspection shall be made by an official sanitarian or a person designated by him.

c. A third herd milk sample shall be taken. If this sample also indicates a leucocyte count of 1,500,000 or more per ml, the milk regulatory authority shall, if he deems it necessary, require the producer to:

1. Have milking equipment analyzed by a milk equipment serviceman.

2. Have individual animals examined by a veterinarian. Cows producing abnormal milk shall be milked separately and the milk shall be withheld from the milk supply.

Phase III - Effective July 1, 1970. A penalty clause shall be added for non-compliance with leucocyte standards. Milk supplies having 1,500,000 or more leucocytes per ml.on three out of five of the last tests and continued violations of applicable items of sanitation(1r and/or 14r of PHS Ordinance) shall have their permit suspended and/or court action shall be taken in accordance with Section 3 and/or 6 of the 1965 PHS Ordinance: provided that leucocyte counts of 1,500,000 or more per ml.shall not have been officially recorded nor penalty applied unless corroborated by the direct microscopic leucocyte count or the equivalent as published by the USPHS and subjected to the State Laboratory Certification Program.



Cross Section
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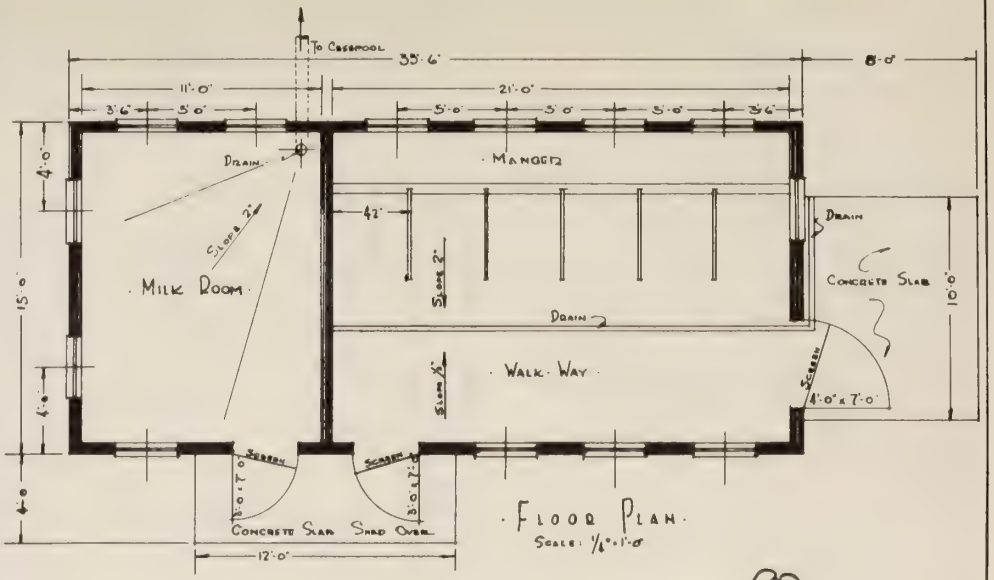
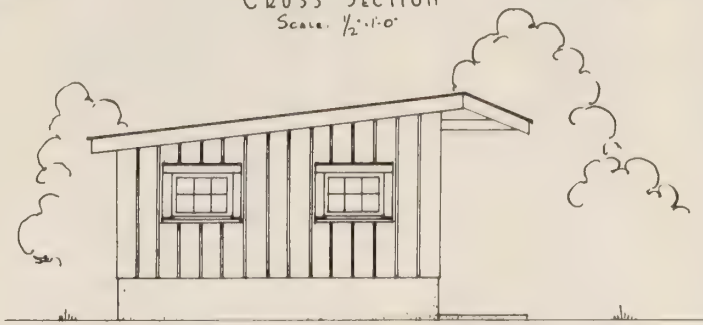
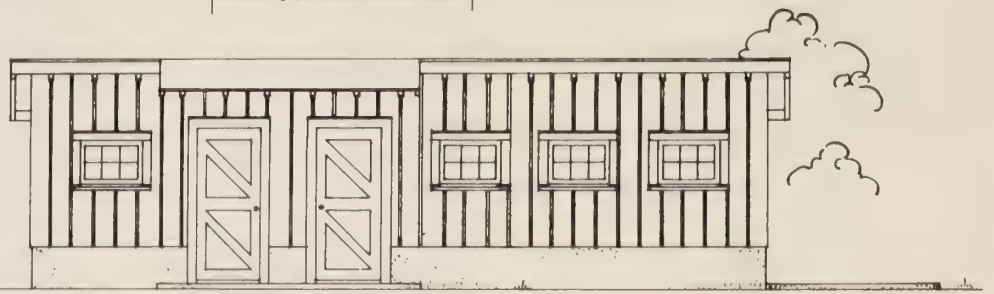


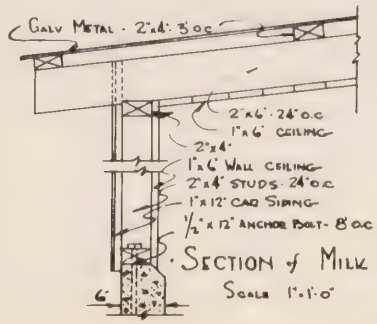
Floor Plan
Scale: 1/4"=1'0"



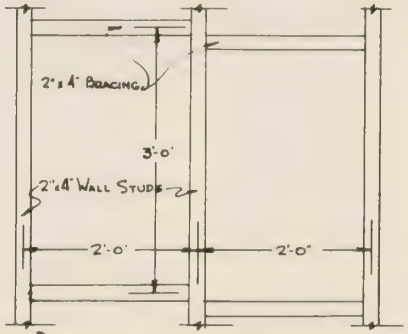
Left Elevation
Scale 1/4"=1'0"



Front Elevation
Scale: 1/4"=1'0"



Section of Milk Room
Scale 1"=1'0"



Detail of Stud Bracing
Scale: 1"=1'0"

Note! The minimum height of the concrete wall from the floor level should be 1'6". However, the concrete wall may be extended to the height of the window sill if desired.

Note! The milk and wash room must be ceiled throughout. It is preferable to have the wall ceiling put on vertically to facilitate cleaning.

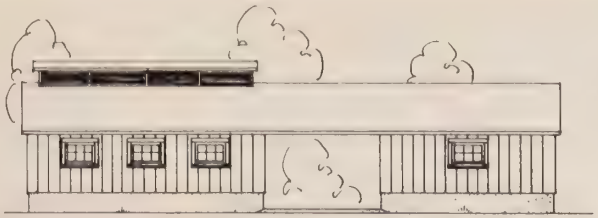
Minimum Sizes of Milk Rooms

Milk Output:	Min. Room Size:
Under 50 Gal.	12'x12' or 144 Sq. Ft.
50 - 100 Gal.	12'x14' or 168 Sq. Ft.
100 - Gal.	12'x16' or 192 Sq. Ft.

Cooperative Extension Work
In Agriculture and Home Economics
Louisiana State University & A & M College
& U.S.D.A. Cooperating

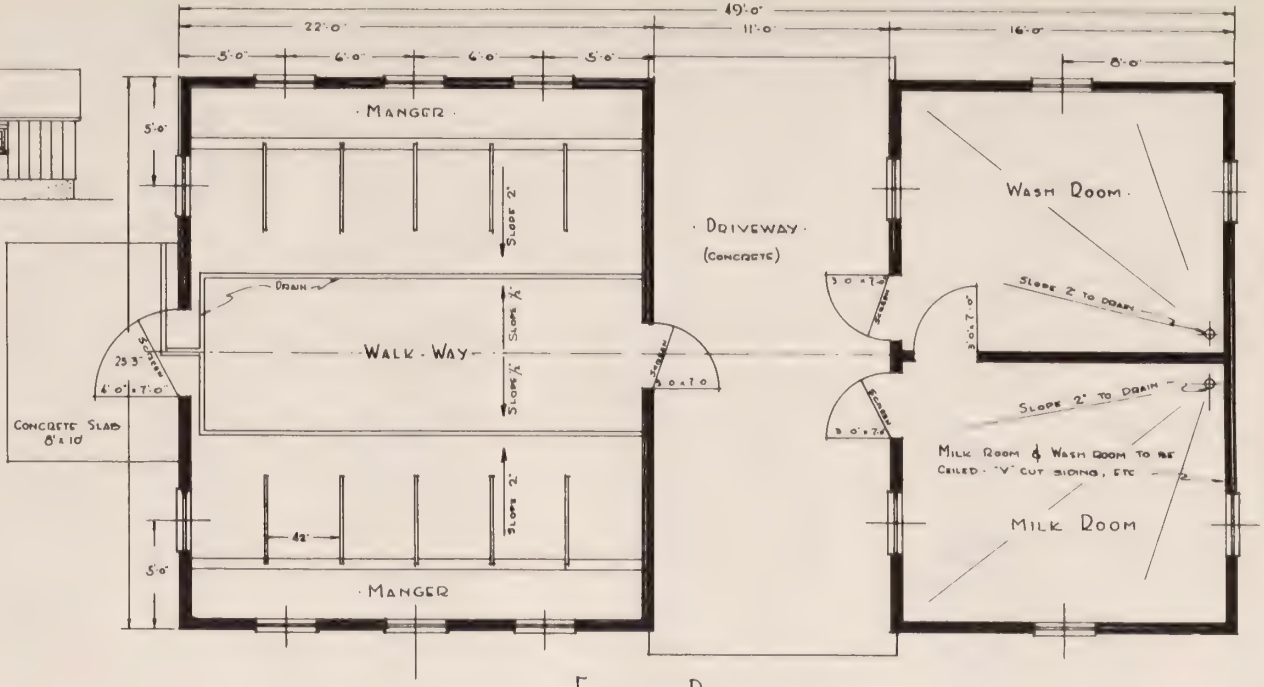
Six Cow Dairy Barn

Drawn By: J.B. Carter	Sheet 1-of-1	No. 4005
Traced By: J.D. Carter	April, 1941	Approved By: H.L. McAndrew
Checked By: C.J. Ferguson		

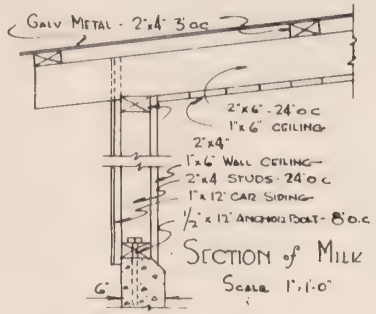


FRONT ELEVATION
Scale: 1/8" = 1'-0"

END ELEVATION
Scale: 1/8" = 1'-0"



FLOOR PLAN
Scale: 1/4" = 1'-0"



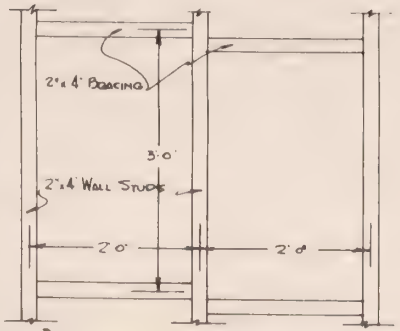
SECTION of MILK ROOM
Scale 1"=1'-0"

Note! The minimum height of the concrete wall from the floor level should be 1'-6". However, the concrete wall may be extended to the height of the window sill if desired.

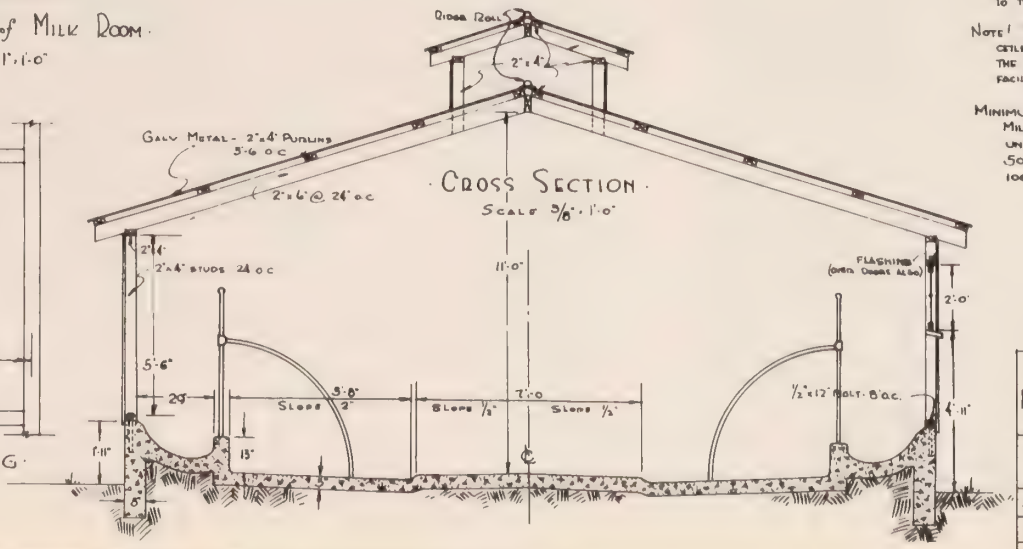
Note! The milk and wash room must be ceiled throughout. It is preferable to have the wall ceiling put on vertically to facilitate cleaning.

Minimum Sizes of Milk Rooms:

Milk Output:	Min. Room Size:
Under 50 Gal	12' x 12' or 144 sq ft
50 - 100 Gal	12' x 14' or 168 sq ft
100 - Gal.	12' x 16' or 192 sq ft



DETAIL of STUD BRACING
Scale 1"=1'-0"



CROSS SECTION
Scale 3/8" = 1'-0"

COOPERATIVE EXTENSION WORK
IN AGRICULTURE AND HOME ECONOMICS
LOUISIANA STATE UNIVERSITY & A. & M. COLLEGE
& U. S. D. A. COOPERATING

TWELVE COW DAIRY BARN

DRAWN BY: J.D. CARTER	SHEET 1 of 1	No. 4008
TRACED BY: J.D. CARTER	APRIL, 1941	APPROVED BY: H.L.M. Andrews
CHECKED BY: C.J. RUSHMORE		

Chapter XVIII

Frozen Desserts

Some Problems in Frozen Desserts Manufacture and Identification.

The tendency to reduce the amount of butter fat in ice cream and to use increasing amounts of nonfat solids has necessitated the use of new designations to prevent confusion of such products with ice cream in cases where the butterfat content has been reduced below the standards of identity. A number of nonfat milk-solids products have been manufactured for use in such frozen desserts. Due to lack of solubility of lactose (milk sugar) in cold water, when the nonfat milk solids are raised to 12% or above, the lactose tends to crystallize and produce a grittiness or sandiness. Various techniques for producing such high non-fat milk solids products have been deviced, some satisfactory and some not.

The use of alkalies in milk and cream destined for use in ice cream has been argued for by some manufacturers with the claim that such alkalies as sodium bicarbonate, magnesium oxide, magnesium carbonate, calcium oxide, calcium hydroxide, and calcium sucrate be recognized as optional ingredients because they also add other desirable qualities to the ice cream. This has not been recognized, and has been distinctly discouraged by the Federal Food and Drug Administration since such allowance would hinder the work of agencies which long and successfully have been attempting to improve the sanitary quality of dairy products used in frozen desserts, and the addition of these alkalies would result in the concealment of the presence of unfit milk products.

Occasionally batches of ice cream have the appearance of being "wet" or not fully frozen. Sometimes there is a partial separation of the casein in curdlike particles. Sometimes there is difficulty in cooling the mix after pasteurization and homogenization due to its becoming too thick to flow freely; this is often caused by the clumping together of particles of fat. Occasionally, different batches of ice cream prepared by the same formula show differences in apparent smoothness and richness. These difficulties often arise from the improper adjustment of certain mechanical equipment used in preparing the mix or freezing the ice cream. Most, if not all, of the difficulties will occur if dairy ingredients be used in which souring has progressed to some degree, and in such cases the use of small quantities of the alkalies referred to above will correct the trouble, but such use is subject to the objection expressed above. Some persons advance the theory that these difficulties may also arise occasionally when the mechanical equipment is in proper adjustment and the dairy ingredients used are sweet. In such circumstances these persons ascribe the difficulties to a condition of the mineral salts naturally present in milk which condition they call lack of salt balance. They describe this as an abnormal relationship in the relative proportions of calcium and magnesium ions on the one hand to phosphate and citrate ions on the other. To correct a deficiency in calcium or magnesium ions these persons recommend the use of calcium chloride or calcium lactate, and for a deficiency in phosphate or citrate ions they recommend the use of sodium citrate, disodium phosphate, or sodium metaphosphate. The use of such salts, except disodium phosphate (in not more than 0.2% by weight of the ice cream to prevent undue thickening of the mix) in a mix characterized by cacoa ingredients has been quite limited. When adequate precautions are adopted to eliminate dairy products in which incipient souring has occured there is no established need for the use of either alkalies or salts. The evidence available does not establish that lack of salt balance is the causative factor in the difficulties listed above or that the addition of the mineral salts serves any legitimate purpose except in the case of ice cream characterized by cacao ingredients.

Several products made by adding alkalies to skim milk, concentrating the mixture and drying it to a powder, are sold under trade names to ice cream manufacturers with representations that by the use of such products the nonfat milk solids can be increased without danger of sandiness. There has been advocated a mixture of an alkali-treated dried skim milk and dried egg yolk, claiming that its egg yolk content causes a change in texture and permits a high overrun. Another such product, prepared by adding calcium and magnesium hydroxide and disodium phosphate to skim milk and drying, has been advocated for use. The use of such

alkalies neutralizes the natural acidity of the skim milk. Whether or not such neutralized dried skim milk retards the crystallization of lactose in ice cream is not established by the evidence. To the extent that these products may be overneutralized and serve as vehicles for the introduction of alkalies into ice cream, their use is subject to the same objection as the direct addition of such alkalies. When they are not overneutralized their incorporation in any substantial proportion in the ice cream mix dilutes the acidity of the mix and makes possible the use of larger quantities of dairy ingredients in which souring has occured. The evidence does not establish that such products have a legitimate place in ice cream.

Carotene (provitamin A) has been proposed as an optional ingredient of ice cream for the purpose of enhancing its nutritive value. The evidence does not establish that carotene is stable and retains its potency in ice cream. Ice cream is consumed in relatively small quantities, particularly by those groups whose diet is likely to be deficient in vitamin A. It is not known that, even if carotene retains its potency in ice cream, the quantity of vitamin A contributed to such diets would be of any substantial significance. It has not been shown that carotene would otherwise serve a useful purpose in ice cream. To avoid confusing and misleading consumers, the fortification of foods with vitamins should be restricted to a few stable foods which are effective carriers of the particular vitamins that are deficient in the diet of a significant segment of the population who regularly consume these foods.

Many kinds of ice cream are colored. When so used that they do not create a misleading impression as to the presence of a natural ingredient or the amount of a natural ingredient present, colorings are suitable ingredients of ice cream.

Each State and the District of Columbia have established through law or regulation minima for the fat content of ice cream.

The characteristic smoothness and texture and the characteristic richness in taste and food values expected in ice cream by consumers are produced primarily by the content of milk fat, nonfat milk solids, and other solids in the mix, by the homogenization of the mix, and by the technique of freezing. Of all these factors, the quantity of milk fat has the greatest influence on such characteristics.

The characterizing ingredients, such as cocoas, fruits, nuts, malted milk, candy, cakes, cookies, cooked cereals, and glaced fruits are bulky, that is, they must be used in relatively large quantities in order to characterize ice cream. When such quantities are added to an ice cream mix, the fat content of the finished ice cream will be lowered in proportion to the quantity of such characterizing ingredients used. This is recognized in practically all State standards. A considerable number of States permit a reduction in fat content proportionate to the quantity of such characterizing ingredients, but provide that in no case shall the reduction be more than 2 percent. Many States provide for a flat reduction of 2 percent. Most State standards limit the reduction to not more than 2 percent below the minimum prescribed for ice cream characterized by non-bulky ingredients. The characterizing ingredients, such as ground spices, ground vanilla beans, infusions of coffee or tea, extracts of lemon and vanilla, various artificial food flavors, wines, liqueurs, and the like are used in relatively small quantities and do not significantly lower the fat content of the mix. The characterizing and sweetening ingredients, such as maple syrup, maple sugar, honey, etc., replace other sweetening agents and do not lower the fat content of the mix. When the fat content in ice cream is low (8 percent to 10 percent), it is customary to use 10 percent to 12 percent of nonfat milk solids. In high-fat ice cream the content of nonfat milk solids is lower, but even in the case of very high-fat ice cream, it does not fall below about 6 percent. A minimum of 6 percent by weight of nonfat milk solids in ice cream is a reasonable limitation.

When ice cream mix is frozen, air is whipped in and the volume of finished ice cream is greater than the volume of the original mix. This increase in volume is known in the trade as "overrun". The amount of overrun depends mainly on the vigor of whipping, the temperature of freezing, and the composition of the mix. A certain amount of overrun is necessary to give ice cream some of its characteristic properties, but ice cream can be excessively inflated and

thus cheapened, since it is sold by volume. As the amount of air is increased,the weight of a given volume of the ice cream decreases. It is practicable in manufacturing ice cream to control the quantity of overrun with either of the two types of freezers in general use, that is, the batch type and the continuous type. Most of the State standards limit the overrun either by establishing a minimum weight per gallon for the finished ice cream or by other provisions. An overrun of more than approximately 100 percent is excessive. A requirement that the weight of ice cream not be less than 4.5 pounds per gallon, coupled with a minimum limit on solids per gallon permits an overrun of about 100 percent. This is effective in preventing the excessive incorporation of air, and is reasonable.

Excessive water in ice cream mix dilutes its solids content and cheapens the product. A reasonable limitation against excessive dilution is a requirement that the solids content be not less than 1.6 pounds per gallon of finished ice cream. Such a requirement also serves as a desirable adjunct to the method of controlling overrun, since it allows higher overrun in the case of higher solids content and restricts overrun in the case of lower solids content.

Frozen custard, french ice cream, and french custard ice cream are common and usual names for the food which is identical with ice cream except that it contains eggs or egg yolk in such quantity that the egg yolk solids are not less than 1.4 percent of the weight of the finished food. Therefore everything observed above about ice cream also applies to frozen custard.

Ice milk which closely resembles ice cream but which usually contains only about 4 or 5 percent of milk fat is sold in several states. In comparison with the volume of ice cream, the quantity of ice milk sold is small. A number of states define the product as an imitation ice cream. Some states define ice cream and prescribe restrictions designed to safeguard against its sale as ice cream. Among such safeguards are: Sale is permitted only in packages conspicuously labeled ice milk; the size of the packages is limited to not more than 1 pint or other relatively small quantity; sale is restricted to establishments which sell no other frozen desserts; establishments selling the product are required to display signs in letters of specified height bearing such inscriptions as "Ice milk sold here". A large proportion of this product is used in certain soda fountain beverages. Consumers do not generally distinguish ice milk from ice cream. It is easily passed off as and for ice cream, and sometimes is so passed off.

The quantity of milk constituent solids necessary to characterize fruit sherbet is at least 2 percent by weight of the finished product. More than 5 percent of such solids tends to make the product resemble ice cream, as does a quantity of milk fat above 2 percent. Maxima of not more than 5 percent total milk constituent solids and not more than 2 percent milk fat, and minima of not less than 2 percent total milk constituent solids and not less than 1 percent milk fat, are necessary to characterize fruit sherbet and to differentiate it from ice cream and water ice.

Besides the usual stabilizers allowed for ice cream, egg white has also been found suitable in fruit sherbet. Pectin is also suitable for use for this purpose in a quantity not more than 0.5 percent by weight.

Most State laws defining sherbet are designed to prevent its manufacture in simulation of ice cream. One requirement of many such laws is that the acidity of the product not be less than 0.35 percent, calculated as lactic acid. The acidity of sherbet averages about 0.5 to 0.6. A minimum of 0.35 acidity, calculated as lactic acid, is a reasonable limit for fruit sherbet. To reach the desired acidity harmless acids are usually added. Those generally used and suitable for use are citric, tartaric, lactic, and malic.

Salt and eggs or egg yolks are sometimes present in fruit sherbet as a result of the use of ice cream mix in its preparation. The quantity of egg yolk solids thus introduced is less than 1/2 or 1 percent.

Much fruit sherbet is colored. When so used that they do not create a misleading impression as to the quantity of fruit or fruit juice present, colorings are suitable ingredients of fruit sherbet.

Some frozen foods sold as fruit sherbet contain no fruit or fruit juice but are characterized by natural or artificial fruit flavoring, including extracts or emulsions of citrus oils. These same flavorings are frequently used as "kickers" with some fruit or fruit juice, that is, they enhance the fruity characteristics of the finished product to an intensity that would otherwise be reached only by using more fruit or fruit juice. Such flavorings produce a given flavor intensity at a lesser cost than does fruit or fruit juice. The most important and expensive single constituent of fruit sherbet is fruit or fruit juice. Authorization to use such flavorings in any frozen product having the apparent characteristics of fruit sherbet would tend to deception of consumers.

The normal overrun in fruit sherbet is less than that in ice cream. A requirement that the weight of fruit sherbet not be less than 6 pounds per gallon is effective in preventing the excessive incorporation of air, and is a reasonable limit.

Most of the commercially produced water ices are characterized by their fruity flavor and are of the same composition as the correspondingly flavored commercial fruit sherbets except that no dairy ingredient is used in water ice. Some nonfruity-type water ices are produced, but there is insufficient evidence to determine what the composition and characteristics of each of such various products should be.

There are other frozen foods which differ from ice cream, fruit sherbet, and fruit-type water ice. They are not sold under these names, but usually are referred to collectively as "frozen confections." It has been proposed that a definition and standard of identity be prescribed for these articles under the name "frozen confections". The composition and characteristics of these articles are so varied that no blanket requirement sufficiently definitive to be of substantial significance to consumers is practicable.

Ice cream is essentially a product made of cream or a mixture of cream and milk. The tendency at present to substitute vegetable and animal fats for milk fat in ice cream must be recognized, but such substitution necessitates the change of name of such product to something other than ice cream. These vegetable and animal fats are harmless and nutritive and should be fortified with vitamins at least to the extent of butter fat if used in place of butter fat in ice cream or other frozen desserts products. The use of vegetable and animal fats also requires the use of more stabilizer to retard the formation of large ice crystals and in some cases to improve the whipping quality of the mix than is used in a cream product. If such fats be used in frozen desserts, definitions and standards of identity should be worked out. To date, this has not been done by the Federal Food and Drug Administration, but in some states such as Alabama, Arkansas, Texas, Oklahoma, Missouri, Louisiana, Illinois, California, and Oregon such definitions and standards of identity have been set up and various names have been given them, such as Mellorine, Olarine, Sherine, Fruit Sherine.

The problem of selling these products retail in bulk over the counter has caused complications because they may very easily be confused with ice cream and misrepresented by some unscrupulous dealers.

The Federal Food and Drug Administration drafted a set of definitions and standards for frozen desserts in 1942 which were not promulgated but were used as models by many states until December 15, 1964 when a new set of standards were promulgated, based on the 1942 draft, and which are presented below:

Definitions and Standards of Identity

Ice cream; identity; label statement of optional ingredients.

(a) Ice cream is the food prepared by freezing, while stirring, a pasteurized mix composed of one or more of the optional ingredients specified in paragraph (c) of this section, sweetened with one or more of the optional sweetening ingredients specified in paragraph (d) of this section. One or more of the optional characterizing ingredients specified in paragraph (b) of this section and one or more of the optional ingredients specified in paragraph (d) (5) to (10) may be used to characterize the ice cream. One or more of the optional caseinates specified in paragraph (e) and one or more of the optional ingredients specified in paragraph (f) of this section may be used, subject to the conditions hereinafter set forth. The mix may be

seasoned with salt, and may be homogenized. The kind and quantity of optional dairy ingredients used, as specified in paragraph (c) of this section, and the content of milk fat and nonfat milk solids therein, are such that the weights of milk fat and total milk solids are not less than 10 percent and 20 percent, respectively, of the weight of the finished ice cream; but in no case shall the content of milk solids-not-fat be less than 6 percent except that when one or more of the bulky optional ingredients as specified in paragraph (b) (3) to (8), inclusive, of this section, are used, the weights of milk fat and total milk solids (exclusive of such fat and solids in any malted milk used) are not less than 10 percent and 20 percent, respectively, of the remainder obtained by subtracting the weight of such optional ingredients, modified as prescribed in this paragraph, from the weight of the finished ice cream; but in no case is the weight of milk fat or total milk solids less than 8 percent and 16 percent, respectively, of the weight of the finished ice cream. The optional caseinates specified in paragraph (e) of this section are not deemed to be milk solids. In calculating the reduction of milk fat and total milk solids from the use of bulky optional ingredients, chocolate and cocoa solids used shall be considered the bulky ingredients of paragraph (b) (3) of this section. In order to make allowance for additional sweetening ingredients needed when bulky ingredients are used, the weight of chocolate or cocoa solids may be multiplied by 2.5; the weight of fruit or nuts used may be multiplied by 1.4; and the weight of partially or wholly dried fruits or fruit juices may be multiplied by appropriate factors to obtain the original weights before drying and this weight multiplied by 1.4. The finished ice cream contains not less than 1.6 pounds of total solids to the gallon and weighs not less than 4.5 pounds to the gallon; except that when the optional ingredient microcrystalline cellulose specified in paragraph (f) (6) of this section is used, the finished ice cream contains not less than 1.6 pounds of total solids to the gallon and weighs not less than 4.5 pounds to the gallon exclusive, in both cases, of the weight of the microcrystalline cellulose. Artificial flavoring in any chocolate, cocoa, confectionery, or other ingredient used is an optional ingredient of the finished ice cream. Coloring, including artificial coloring, may be added. [1]

(b) The optional characterizing ingredients referred to in paragraph (a) of this section are:

(1) Ground spice, ground vanilla beans, infusion of coffee or tea, or any natural food flavoring.

(2) Artificial food flavoring.

(3) Chocolate or cocoa, which may be added as such or as a suspension in syrup, and which may contain disodium phosphate or sodium citrate in such quantity that the finished ice cream contains not more than 0.2 percent by weight of disodium phosphate or sodium citrate. For the purposes of this section, the term "cocoa" means one or any combination of two or more of the following: Cocoa, breakfast cocoa, low-fat cocoa, and the unpulverized residual material prepared by removing part of the fat from ground cacao nibs.

(4) Mature fruit or the juice of mature fruit, either of which may be fresh, frozen, canned, concentrated, or partially or wholly dried. The fruit may be whole, shredded, or comminuted; it may be sweetened, thickened with pectin or with one or more of the ingredients named in paragraph (f) (2) of this section, subject to the restriction on the total quantity of such substances in ice cream prescribed in that paragraph, and it may be acidulated with citric acid, ascorbic acid, or phosphoric acid. The fruit is prepared by the removal of pits, seeds, skins, and cores, where such removal is usual in preparing that kind of fruit for consumption as fresh fruit. In the case of fruit or fruit juice from which part of the water is removed, the substances contributing flavor volatilized during water removal may be condensed and reincorporated in the concentrated fruit or fruit juice. In the case of the citrus fruits the whole fruit, including the peel but excluding the seeds, may be used, and in the case of citrus juice or concentrated citrus juice, cold-pressed citrus oil may be added in an amount not exceeding that which would have been obtained if the peel from the whole fruit had been used. For the purposes of this section, the flesh of the coconut shall be considered a fruit.

1. Section 403 (k) of the Federal Food, Drug, and Cosmetic Act grants label declaration exemption for artificial coloring in ice cream.

(5) Nut meats, which may be roasted, cooked in an edible fat or oil, or preserved in syrup, and which may be salted.

(6) Malted milk.

(7) Confectionery. For the purposes of this section, the term "confectionery" means candy, cakes, cookies, and glaceed fruits.

(8) Properly prepared and cooked cereal.

(9) Distilled alcoholic beverage, including liqueurs or wine, in an amount not to exceed that required for flavoring the ice cream.

(c) The optional dairy ingredients referred to in paragraph (a) of this section are: Cream, dried cream, plastic cream (sometimes known as concentrated milk fat), butter, butter oil, milk, concentrated milk, evaporated milk, sweetened condensed milk, superheated condensed milk, dried milk, skim milk, concentrated skim milk, evaporated skim milk, condensed skim milk, superheated condensed skim milk, sweetened condensed skim milk, sweetened condensed part-skim milk, nonfat dry milk, sweet cream buttermilk, condensed sweet cream buttermilk, dried sweet cream buttermilk, skim milk that has been concentrated and from which part of the lactose has been removed by crystallization, skim milk in concentrated or dried form which has been modified by treating the concentrated skim milk with calcium hydroxide and disodium phosphate, concentrated cheese whey, and dried cheese whey. Water may be added, or water may be evaporated from the mix. The sweet cream buttermilk and the concentrated sweet cream buttermilk or dried sweet cream buttermilk, when adjusted with water to a total solids content of 8.5 percent, has a titratable acidity of not more than 0.17 percent, calculated as lactic acid. The term "milk" as used in this section means cow's milk. Any concentrated cheese whey and dried cheese whey used contribute not more than 25 percent by weight of the total nonfat milk solids content of the finished food. Dried cheese whey is uniformly light in color, free from brown and black scorched particles, and has an alkalinity of ash, not more than 0.17 percent, calculated as lac-100 grams, a bacterial count of not more than 50,000 per gram, and, as adjusted with water to a total solids content of 6.5 percent, a titratable acidity of not more than 0.16 percent, calculated as lactic acid. Concentrated cheese whey has an alkalinity of ash, not more than 115 milliliters 0.1N HCl per 100 grams, a bacterial count of not more than 50,000 per gram, and, as adjusted with water to a total solids content of 6.5 percent, a titratable acidity of not more than 0.18 percent, calculated as lactic acid. The modified skim milk, when adjusted with water to a total solids content of 9 percent, is substantially free of lactic acid as determined by titration with 0.1N NaOH and it has a pH value in the range of 8.0 to 8.3.

(d) The optional sweetening ingredients referred to in paragraph (a) of this section are:

(1) Sugar (sucrose) or sugar syrup.
(2) Dextrose.
(3) Invert sugar (in paste or syrup form).
(4) Corn syrup, dried corn syrup, glucose syrup, dried glucose syrup.
(5) Maple syrup, maple sugar.
(6) Honey.
(7) Brown sugar.
(8) Malt syrup, maltose syrup, malt extract.
(9) Dried malt syrup, dried maltose syrup, dried malt extract.
(10) Refiner's syrup.
(11) Molasses (other than black-strap).
(12) Lactose.
(13) Fructose.

(e) The optional caseinates referred to in paragraph (a) of this section which may be added to ice cream mix containing not less than 20 percent total milk solids are: Casein prepared by precipitation with gums, ammonium caseinate, calcium caseinate, potassium caseinate, and sodium caseinate. Caseinates may be added in liquid or dry form, but must be free of excess alkali.

(f) Other optional ingredients referred to in paragraph (a) of this section are:

(1) Liquid eggs, frozen eggs, dried eggs, egg yolks, frozen egg yolks, and dried egg yolks. Any egg ingredient used is added to the mix before it is pasteurized. The total weight of egg yolk solids in the finished ice cream from one or a combination of two or more such ingredients is less than the minimum prescribed for frozen custard, i.e., 1.4 percent.

(2) Agar-agar, algin (sodium alginate), calcium sulfate, gelatin, gum acacia, guar seed gum, gum karaya, locust bean gum, oat gum, gum tragacanth, carrageenan, salts of carrageenan, furcelleran, salts of furcelleran, lecithin, psyllium seed husk, sodium carboxymethylcellulose. The total weight of the solids of any such ingredient used singly or of any combination of two or more such ingredients used (including any such ingredient and pectin added separately to the fruit ingredient) is not more than 0.5 per cent of the weight of the finished ice cream. Such ingredients may be added in admixture with dextrin, propylene glycol, or glycerin.

(3) Monoglycerides or diglycerides or both of fat-forming fatty acids. The total weight of such ingredients is not more than 0.2 percent of the weight of the finished ice cream. If the preparation used be one having a high proportion of monoglycerides (over 90 percent), it may be preblended with edible fat, but the amount of such fat does not exceed 20 percent by weight of the blend, and the total amount of the blend used does not exceed 0.2 percent of the weight of the finished ice cream.

(4) Polyoxethylene (20) sorbitan tristearate, polysorbate 80, or both (complying with the provisions of this chapter including the limit on either used separately or both used in combination of not more than 0.1 percent by weight of the finished frozen dessert).

(5) Propylene glycol alginate (complying with the provisions of this chapter including the limit of not more than 0.5 percent by weight of the finished frozen dessert).

(6) Microcrystalline cellulose, in a quantity not to exceed 1.5 percent by weight of the finished frozen dessert.

(7) When one or more of the optional thickening ingredients in subparagraph (2) or (5) of this paragraph are used, dioctyl sodium sulfosuccinate complying with the requirements of this chapter may be used in a quantity not in excess of 0.5 percent by weight of such ingredients.

(8) (i) Sodium citrate, disodium phosphate, tetrasodium pyrophosphate, sodium hexametaphosphate, or any combination of two or more of these; but the total quantity of the solids of such ingredients (exclusive of any disodium phosphate or sodium citrate present in chocolate or cocoa, as permitted by paragraph (b) (3) of this section) is not more than 0.2 percent by weight of the finished ice cream.

(ii) Calcium oxide, magnesium oxide, calcium hydroxide, magnesium hydroxide, or any combination of two or more of these; but the total quantity of the solids of such ingredients is not more than 0.04 percent of the weight of the finished ice cream.

(g) (1) The name of the food is "ice cream".

(2) (i) If the food contains no artificial flavor, the name on the principal display panel or panels of the label shall be accompanied by the common or usual name of the characterizing flavor, e.g., "vanilla," in letters not less than one-half the height of the letters used in the words "ice cream".

(ii) If the food contains both a natural characterizing flavor and an artificial flavor simulating it, and if the natural flavor predominates, the name on the principal display panel or panels of the label shall be accompanied by the common name of the characterizing flavor, in letters not less than one-half the height of the letters used in the words "ice cream," followed by the word "flavored," in letters not less than one-half of the height of the letters in the name of the characterizing flavor, e.g., "VANILLA flavored," or "PEACH flavored," or "VANILLA flavored and STRAWBERRY flavored".

(iii) If the food contains both a natural characterizing flavor and an artificial flavor simulating it, and if the artificial flavor predominates, or if artificial flavor be used alone, the name on the principal display panel or panels of the label shall be accompanied by the common name of the characterizing flavor, in letters not less than one-half the height of the letters used in the words "ice cream," preceded by "artificial" or "artificially flavored," in letters not less than one-half the height of the letters in the name of the characterizing flavor, e.g., "artificial VANILLA," or "artificially flavored STRAWBERRY" or "artificially flavored VANILLA and artificially flavored STRAWBERRY".

(3) (i) If the food be subject to the requirements of subparagraph (2) (ii) of this paragraph or if it contains any artificial flavor not simulating the characterizing flavor, the label

shall also bear the words "artificial flavor added" or "artificial _____ flavor added," the blank being filled with the common name of the flavor simulated by the artificial flavor in letters of the same size and prominence as the words that precede and follow it.

(ii) When the optional ingredient microcrystalline cellulose specified in paragraph (f) (6) of this section is used, the label shall bear the statement "microcrystalline cellulose added" or "with microcrystalline cellulose".

(iii) When two or more of the optional ingredients specified in paragraphs (b) (2) and (f) (6) of this section are used, such words may be combined; for example "microcrystalline cellulose and artificial flavor added".

(iv) Wherever the name of the characterizing flavor appears on the label so conspicuously as to be easily seen under customary conditions of purchase, the words prescribed by this subparagraph shall immediately and conspicuously precede or follow such name, in a size reasonably related to the prominence of the name of the characterizing flavor and in any event the size of the type is not less than 6-point on packages containing less than 1 pint, not less than 8-point on packages containing at least 1 pint but less than one-half gallon, not less than 10-point on packages containing at least one-half gallon but less than 1 gallon, and not less than 12-point on packages containing 1 gallon or over; Provided, however, That where the characterizing flavor and a trade mark or brand are presented together, other written, printed, or graphic matter that is a part of or is associated with the trade mark or brand, may intervene if the required words be in such relationship with the trade mark or brand as to be clearly related to the characterizing flavor: And provided further, That if the finished product contains more than one flavor of ice cream subject to the requirements of this subparagraph, the statements required by this subparagraph need appear only once in each statement of characterizing flavors present in such ice cream, e.g., "VANILLA flavored, CHOCOLATE and STRAWBERRY flavored artificial flavors added".

(4) If the food contains both a natural characterizing flavor and an artificial flavor simulating the characterizing flavor, any reference to the natural characterizing flavor shall, except as otherwise authorized by this paragraph, be accompanied by a reference to the artificial flavor, displayed with substantially equal prominence, e.g., "strawberry and artificial strawberry flavor".

(5) An artificial flavor simulating the characterizing flavor shall be deemed to predominate:

(i) In the case of vanilla beans or vanilla extract used in combination with vanillin, if the amount of vanillin used be greater than 1 ounce per unit of vanilla constituent, as that term is defined in this chapter.

(ii) In the case of fruit or fruit juice used in combination with artificial fruit flavor, if the quantity of the fruit or fruit juice used be such that, in relation to the weight of the finished ice cream, the weight of the fruit or fruit juice, as the case may be (including water necessary to reconstitute partially or wholly dried fruits or fruit juices to their original moisture content) be less than 2 percent in the case of citrus ice cream, 6 percent in the case of berry or cherry ice cream, and 10 percent in the case of ice cream prepared with other fruits.

(iii) In the case of nut meats used in combination with artificial nut flavor, if the quantity of nut meats used be such that, in relation to the finished ice cream, the weight of the nut meats be less than 2 percent.

(iv) In the case of two or more fruits or fruit juices, or nut meats, or both, used in combination with artificial flavors simulating the natural flavors and dispersed throughout the food, if the quantity of any fruit or fruit juice or nut meat be less than one-half the applicable percentage specified in subdivision (ii) or (iii) of this subparagraph. For example, if a combination ice cream contains less than 5 percent of bananas and less than 1 percent of almonds, it would be "Artificially flavored banana-almond ice cream". However, if it contains more than 5 percent of bananas and more than 1 percent of almonds, it would be "Banana-almond flavored ice cream".

(6) If two or more flavors of ice cream be distinctively combined in one package, e.g., "Neapolitan" ice cream, the applicable provisions of this paragraph shall govern each flavor of ice cream comprising the combination.

Frozen custard, french ice cream, french custard ice cream; identity; label statement of optional ingredients.

Frozen custard, french ice cream, french custard ice cream conform to the definition and

standard of identity, and are subject to the requirements for label statement of optional ingredients, prescribed for ice cream, except that one or more of the optional egg ingredients permitted for ice cream in (f) (1) are used in such quantity that the total weight of egg yolk solids therein be not less than 1.4 percent of the weight of the finished frozen custard: Provided, however, That when the ingredients named for ice cream in (b) (3) through (8), inclusive, are used, the content of egg yolk solids may be reduced in proportion to the bulk ingredient or ingredients added, under the conditons prescribed under ice cream in (a) for reduction in milk fat and total milk solids; but in no case is the content of egg yolk solids less than 1.12 percent.

Ice milk; identity; label statement of optional ingredients.

Ice milk is the food prepared from the same ingredients and in the same manner prescribed for ice cream and complies with all the provisions for ice cream (including the requirements for label statement of optional ingredients), except that:

(a) Its content of milk fat be more than 2 percent but not more than 7 percent.

(b) Its content of total milk solids not be less than 11 percent.

(c) Caseinates may be added when the content of total milk solids is not less than 11 percent.

(d) The provision for reduction in milk fat and total milk solids from the addition of bulky ingredients under ice cream in (a) does not apply.

(e) The quantity of food solids per gallon not be less than 1.3 pounds; except that when the optional ingredient microcrystalline cellulose specified under ice cream in (f) (6) is used, the quantity of food solids per gallon be not less than 1.3 pounds, exclusive of the weight of the microcrystalline cellulose.

(f) When any artificial coloring is used in ice milk, directly or as a component of any other ingredient, the label shall bear the statement "artificially colored," "artificial coloring added," "with added artificial color," or "_____, an artificial color added," the blank being filled in with the common or usual name of the artificial color; or in lieu thereof, in case the artificial color is a component of another ingredient, "_____ artificially colored".

(g) The name of the food be "ice milk".

(h) If both artificial color and artificial flavoring be used, the label statements may be combined.

Fruit sherbets: identity; label statement of optional ingredients.

(a) Fruit sherbets are the foods each of which is prepared by freezing, while stirring, a mix composed of one or more of the optional characterizing fruit ingredients specified in paragraph (b) of this section and one or more of the optional ingredients specified in paragraph (c) of this section, sweetened with one or more of the optional sweetening ingredients specified in paragraph (d) of this section. One or more of the optional ingredients specified in paragraph (e) of this section may be used, subject to the conditions hereinafter set forth. The mix of combined dairy ingredients, with or without other ingredients, is pasteurized. The titratable acidity of the finished fruit sherbet, calculated as lactic acid, is not less than 0.35 percent. The mix with or without added water may be seasoned with salt, and may be homogenized. The optional dairy ingredients used and the content of milk fat and nonfat milk solids therein are such that the weight of milk fat be not less than 1 percent and not more than 2 percent, and the weight of total milk solids be not less than 2 percent and not more than 5 percent of the weight of the finished fruit sherbet. The optional caseinates specified in paragraph (e) (7) of this section are not deemed to be milk solids. The finished fruit sherbet weighs not less than 6 pounds to the gallon; except that when the optional ingredient microcrystalline cellulose specified in paragraph (e) (11) of this section is used, the finished fruit sherbet weighs not less than 6 pounds to the gallon, exclusive of the weight of the microcrystalline cellulose.

(b) The optional fruit characterizing ingredients referred to in paragraph (a) of this

section are any mature fruit or the juice of any mature fruit. The fruit or fruit juice used may be fresh, frozen, canned, concentrated, or partially or wholly dried. The fruit may be thickened with pectin or other of the optional ingredients named in paragraph (e) (2) of this section, subject to the restriction on the total quantity of such substances in fruit sherbets prescribed in that paragraph. The fruit is prepared by the removal of pits, seeds, skins, and cores, where such removal is usual in preparing that kind of fruit for consumption as fresh fruit. The fruit may be screened, crushed, or otherwise comminuted. It may be acidulated with citric acid, ascorbic acid, or phosphoric acid. In the case of concentrated fruit or fruit juices, from which part of the water is removed, substances contributing flavor volatilized during water removal may be condensed and reincorporated in the concentrated fruit or fruit juice. In the case of citrus fruits, the whole fruit, including the peel but excluding the seeds, may be used, and in the case of citrus juice or concentrated citrus juices, cold-pressed citrus oil may be added thereto in an amount not exceeding that which would have been obtained if the whole fruit had been used. The quantity of fruit ingredients used is such that, in relation to the weight of the finished sherbet, the weight of fruit or fruit juice, as the case may be (including water necessary to reconstitute partially or wholly dried fruits or fruit juices to their original moisture content), is not less than 2 percent in the case of citrus sherbets, 6 percent in the case of berry sherbets, and 10 percent in the case of sherbets prepared with other fruits. For the purposes of this section, tomatoes and rhubarb are considered as kinds of fruit.

(c) The optional dairy ingredients referred to in paragraph (a) of this section are: Cream, dried cream, plastic, cream (sometimes known as concentrated milk fat), butter, butter oil, milk, concentrated milk, evaporated milk, superheated condensed milk, sweetened condensed milk, dried milk, skim milk, concentrated skim milk, evaporated skim milk, condensed skim milk, superheated condensed skim milk, sweetened condensed skim milk, sweetened condensed part-skim milk, nonfat dry milk, sweet cream buttermilk, skim milk that has been concentrated and from which part of the lactose has been removed by crystallization, concentrated cheese whey, and dried cheese whey. Water may be added, or water may be evaporated from the mix. The sweet cream buttermilk and the concentrated sweet cream buttermilk or dried sweet cream buttermilk, when adjusted with water to a total solids content of 8.5 percent, has a titratable acidity of not more than 0.17 percent, calculated as lactic acid. The term "milk" as used in this section means cow's milk. Dried cheese whey is uniformly light in color, free from brown and black scorched particles, and has an alkalinity of ash, not more than 225 milliliters 0.1N HCl per 100 grams, a bacterial count of not more than 50,000 per gram, and, as adjusted with water to a total solids contents of 6.5 percent, a titratable acidity of not more than 0.16 percent calculated as lactic acid. Concentrated cheese whey has an alkalinity of ash, not more than 115 milliliters 0.1N HCl per 100 grams, a bacterial count of not more than 50,000 per gram, and, as adjusted with water to a total solids content of 6.5 percent, a titratable acidity of not more than 0.18 percent, calculated as lactic acid.

(d) The optional sweetening ingredients referred to in paragraph (a) of this section are: Sugar(sucrose), dextrose, invert sugar (paste or syrup), glucose syrup, dried glucose syrup, corn syrup, dried corn syrup, malt syrup, malt extract, dried malt syrup, dried malt extract, maltose syrup, dried maltose syrup.

(e) Other optional ingredients referred to in paragraph (a) of this section are:

(1) Liquid eggs, frozen eggs, dried eggs, egg yolks, frozen yolks, dried yolks; but the weight of egg yolk solids therein is less than 0.5 percent of the weight of the finished fruit sherbet.

(2) Agar-agar, algin (sodium alginate), calcium sulfate, egg white, gelatin, gum acacia, guar seed gum, gum karaya, locust bean gum, oat gum, gum tragacanth, hydroxypropyl methylcellulose, carrageenan, salts of carrageenan, furcelleran, salts of furcelleran, lecithin, pectin, psyllium seed husk, sodium carboxymethylcellulose. The total weight of the solids of any such ingredient used singly or of any combination of two or more such ingredients used (including any such ingredient added separately to the fruit ingredient) is not more than 0.5 percent of the weight of the finished fruit sherbet. Such ingredients may be added in admixture with dextrin, propylene glycol, or glycerin.

(3) Monoglycerides or diglycerides or both of fat-forming fatty acids. The total weight of such ingredients is not more than 0.2 per cent of the weight of the finished fruit sherbet. If the preparation used be one having a high proportion of monoglycerides (over 90 percent), it may be preblended with edible fat, but the amount of such fat does not exceed 20 percent by weight of the blend, and the total amount of the blend used does not exceed 0.2 percent of the weight of the finished fruit sherbet.

(4) Polyoxyethylene (20) sorbitan tristearate, polysorbate 80, or both, (complying with the provisions of this chapter including the limit on either used separately or both used in combination of not more than 0.1 percent by weight of the finished frozen dessert).

(5) Propylene glycol alginate (complying with the provisions of this chapter including the limit of not more than 0.5 percent by weight of the finished frozen dessert).

(6) Citric acid, tartaric acid, malic acid, lactic acid, ascorbic acid, phosphoric acid, or any combination of two or more of these in such quantity as seasons the finished food.

(7) Casein prepared by the precipitation with gums, ammonium caseinate, calcium caseinate, potassium caseinate, sodium caseinate.

(8) Any natural food flavoring.

(9) Any artificial flavoring.

(10) Coloring, including artificial coloring.

(11) Microcrystalline cellulose, in a quantity not to exceed 0.5 percent of the weight of the finished fruit sherbet.

(12) When one or more of the optional thickening ingredients in subparagraph (2) or (5) of this paragraph are used, dioctyl sodium sulfosuccinate complying with the requirements of this chapter may be used in a quantity not in excess of 0.5 percent by weight of such ingredients.

(f) The name of each such fruit sherbet is "_____ sherbet," the blank being filled in with the common name of the fruit or fruits from which the fruit ingredients used are obtained. When the names of two or more fruits are included, such names shall be arranged in order of predominance, if any, by weight of the respective fruit ingredients used.

(g) When the optional ingredients artificial coloring or artificial flavoring are used in fruit sherbet they shall be named on the labels as follows:

(1) The label shall designate artificial coloring by the statement "artificially colored," "artificial coloring added," "with added artificial coloring," or "_____ an artificial color added," the blank being filled in with the name of the artificial coloring used.

(2) The label shall designate artificial flavoring by the statement "artificially flavored," "artificial flavoring added," "with added artificial flavoring," or "_____ an artificial flavor added," the blank being filled in with the name of such other ingredient.

(3) Whenever artificial flavoring is not added as such but as a component of some other ingredient, the label shall include the statement "_____ artificially flavored," the blank being filled in with the name of such other ingredient.

(4) When the optional ingredient microcrystalline cellulose specified in paragraph (e) (11) of this section is used, the label shall bear the statement "microcrystalline cellulose added" or "with added microcrystalline cellulose". Label statements may be combined, as for example, "with added artificial flavoring and artificial coloring".

(h) Where one or more of the optional ingredients artificial coloring or artificial flavoring are used and there appears on the label any representation as to the fruit or fruits in the sherbets, such representation shall be immediately and conspicuously accompanied by appropriate label statements as prescribed in paragraph (g) of this section, showing the optional ingredients used.

(i) Wherever the name of the food appears on the label so conspicuously as to be easily seen under customary conditions of purchase, the statements specified in this section, showing the optional ingredients used, shall immediately and conspicuously precede or follow such name without intervening written, printed, or graphic matter.

Water ices; identity: label statement of optional ingredients.

(a) Water ices are the foods, each of which is prepared by freezing, while stirring, a mix composed of one or more of the optional characterizing fruit ingredients specified in paragraph (b) of this section, sweetened with one or more of the optional sweetening ingredients specified in paragraph (c) of this section. One or more of the optional ingredients specified in paragraph (d) of this section may be used, subject to the conditions hereinafter set forth. The titratable acidity of the finished water ice, calculated as lactic acid, is not less than 0.35 percent. The mix, with or without added water, may be seasoned with salt, and may be homogenized. The finished water ice weighs not less than 6 pounds to the gallon.

(b) The optional fruit ingredients referred to in paragraph (a) of this section are any mature fruit or the juice of any mature fruit. The fruit or fruit juice used may be fresh, frozen, canned, concentrated, or partially or wholly dried. The fruit may be thickened with pectin or other of the optional ingredients named in paragraph (d) (1) of this section subject to the restriction on the total quantity of such substances in water ices prescribed in that paragraph. The fruit is prepared by the removal of pits, seeds, skins, and cores where such removal is usual in preparing that kind of fruit for consumption as fresh fruit. The fruit may be screened, crushed, or otherwise comminuted. It may be acidulated with citric acid, ascorbic acid, or phosphoric acid. In the case of fruit or fruit juices from which part of the water is removed, substances contributing flavor volatilized during water removal may be condensed and reincorporated in the concentrated fruit or fruit juice. In the case of citrus fruits, the whole fruit, including the peel but excluding the seeds, may be used, and in the case of citrus juice or concentrated citrus juices, cold-pressed citrus oil may be added thereto in an amount not exceeding that which would have been obtained if the whole fruit had been used. The quantity of fruit ingredients used is such that in relation to the weight of the finished water ice, the weight of fruit or fruit juice as the case may be (including water necessary to reconstitute partially or wholly dried fruits or fruit juices to their original moisture content) is not less than 2 percent in the case of citrus ices, 6 percent in the case of berry ices, and 10 percent in the case of ices prepared with other fruits.

(c) The optional sweetening ingredients referred to in paragraph (a) of this section are: Sugar (sucrose), dextrose, invert sugar (paste or syrup), glucose syrup, dried glucose syrup, corn syrup, dried corn syrup, malt syrup, malt extract, dried malt syrup, dried malt extract, maltose syrup, dried maltose syrup.

(d) Other optional ingredients referred to in paragraph (a) of this section are:

(1) (i) Agar-agar, algin (sodium alginate), egg white, gelatin, gum acacia, guar seed gum, gum karaya, locust bean gum, oat gum, gum tragacanth, hydroxypropyl methylcellulose, carrageenan, salts of carrageenan, furcelleran, salts of furcelleran, propylene glycol alginate, pectin, psyllium seed husk, sodium carboxymethylcellulose. The total weight of the solids of any such ingredient used singly, or of any combination of two or more such ingredients used (including any such ingredient added separately to the fruit ingredient), is not more than 0.5 percent of the weight of the finished water ice. Such ingredients may be added in admixture with dextrin, propylene glycol, or glycerin.

(ii) When one or more of the optional thickening ingredients in subdivision (i) of this subparagraph are used, dioctyl sodium sulfosuccinate complying with the requirements of this chapter may be used in a quantity not in excess of 0.5 percent by weight of such ingredients.

(2) Citric acid, tartaric acid, malic acid, lactic acid, ascorbic acid, phosphoric acid, or any combination of two or more of these in such quantity as seasons the finished food.

(3) Any natural flavoring.

(4) Any artificial flavoring.

(5) Coloring, including artificial coloring.

(e) The name of each such water ice is "_____ ice," the blank being filled in with the common name of the fruit or fruits from which the fruit ingredient used is obtained. When the names of two or more fruits are included, such names shall appear in the order of predominance, if any, by weight of the respective fruit ingredients used.

(f) When the optional ingredients artificial coloring and artificial flavoring are used in

water ices, they shall be named on the labels as follows:

(1) The label shall designate artificial coloring by the statement "artificially colored," "artificial coloring added," "with added artificial coloring," or "_____, an artificial color added," the blank being filled in with the name of the artificial coloring used.

(2) The label shall designate artificial flavoring by the statement "artificially flavored," "artificial flavoring added," "with added artificial flavoring," or "_____, an artificial flavor added," the blank being filled in with the name of the artificial flavoring used. Label statements may be combined, as for example, "flavoring and artificial coloring added".

(g) Where one or more of the optional ingredients artificial coloring or artificial flavoring are used and there appears on the labeling any representation as to the fruit or fruits in the ice, such representation shall be immediately and conspicuously accompanied by appropriate label statements as prescribed in paragraph (f) of this section, showing the optional ingredients used.

(h) Wherever the name of the food appears on the label so conspicuously as to be easily seen under customary conditions of purchase, the statements set out in this section showing the optional ingredients used shall immediately and conspicuously precede or follow such name, without intervening written, printed, or graphic matter.

Regulatory Control of Frozen Desserts

In 1940, the United States Public Health Service published a recommended Frozen Desserts Ordinance which represented the minimum requirements for safe production and distribution of frozen desserts. It is logical to expect that the basic sanitary provisions for dairies supplying dairy products to frozen desserts plants, and the plants themselves are practically the same as for milk production. Therefore, these requirements should be the same as recommended by the U.S. Public Health Service Grade "A" Pasteurized Milk Ordinance. However, because frozen desserts have different definitions than milk, and because the pasteurization temperature is different from milk, therefore regulations for control would be different for frozen desserts than for milk in these two aspects.

In 1963, the U.S.P.H.S. drafted a Frozen Desserts Ordinance and Code for study purposes only which has not been officially finalized for recommendation to the States. As a guide for control of frozen desserts, the sanitarian will be on safe grounds if he uses:

1. The definitions and standards of Identity for frozen desserts by the Federal Food and Drug Administration.
2. The 1965 U.S.P.H.S. Grade "A" Pasteurized Milk Ordinance for dairies supplying dairy products to frozen desserts plants and for the plants themselves.
3. The definitions of the U.S.P.H.S. Frozen Desserts Ordinance and Code drafted for study only in 1963.
4. The pasteurization temperature and thermometers used in the pasteurization of frozen desserts as found in the U.S.P.H.S. Frozen Desserts Ordinance and Code drafted for study only in 1963.

Definitions

Frozen Dessert — a frozen dessert means ice cream, mix, frozen custard, french ice cream, french custard ice cream, ice milk, fruit sherbet, and water ices defined as follows:

Ice Cream is a frozen dessert prepared by freezing a pasteurized mix composed of two or more of the following: milk, milk products, sweetening ingredients, egg ingredients, stabilizers or emulsifiers, harmless flavoring or color and shall contain not more than 0.5 percent by weight of stabilizer, not less than 10 percent by weight of milkfat, and not less than 20 percent by weight of total milk solids; except when fruits, nuts, cocoa or chocolate, malted milk, confectionery or cooked cereal are used for the purpose of flavoring; then it shall contain not less than 10 percent by weight of milkfat and 20 percent by weight of total milk solids, except for such reduction in milkfat and in total milk solids, as is due to the addition of such flavoring, but in no case shall it contain less than 8 percent by weight of milkfat and 16 percent by weight of total milk solids. The finished ice cream shall contain not less than 1.6 pounds of

total solids to the gallon and shall weigh not less than 4.5 pounds to the gallon.

Frozen Custard, French Ice Cream, French Custard Ice Cream are ice cream to which has been added egg ingredients in such quantity that the total weight of egg yolk solids therein is not less than 1.4 percent of the weight of the finished product: Provided, however, That when fruits, nuts, cocoa or chocolate, malted milk, confectionery or cooked cereal are used, the content of egg yolk solids may be reduced in proportion to those flavorings added; but in no case shall the content of egg yolk solids be less than 1.12 percent.

Ice Milk is a frozen dessert prepared by freezing a pasteurized mix composed of two or more of the following: milk, milk products, sweetening ingredients, egg ingredients, stabilizers or emulsifiers and harmless flavoring or color, and it shall contain not more than 0.5 percent by weight of stabilizer, not less than 2 percent or more than 7 percent by weight of milkfat or less than 11 percent by weight of total milk solids. Caseinate may be added when the content of total milk solids is not less than 11 percent. There shall be no reduction in milkfat and total milk solids due to the addition of fruits, nuts, cocoa or chocolate, malted milk, confectionary or cooked cereal. The quantity of food solids shall not be less than 1.3 pounds to the gallon and the finished product shall weigh not less than 4.5 pounds to the gallon.

Fruit Sherbet shall mean the frozen dessert prepared by freezing, while stirring, a pasteurized mix composed of two or more of the following: milk, milk products, fruit ingredients, sweetening ingredients, egg ingredients, stabilizers or emulsifiers and organic acids. Harmless coloring may be added. The titratable acidity of the finished sherbet, calculated as lactic acid shall not be less than 0.35 percent. It shall contain not more than 0.5 percent stabilizer, not less than 1 percent or more than 2 percent by weight of milkfat, and not less than 2 percent or more than 5 percent by weight of total milk solids. The finished sherbet shall weigh not less than 6 pounds to the gallon.

Water Ices are frozen desserts prepared by freezing a mixture composed of two or more of the following: Fruit ingredients, sweetening ingredients, stabilizers or emulsifiers, organic acids and water. Harmless coloring may be added. The titratable acidity of the finished water ice, calculated as lactic acid shall be not less than 0.35 percent. The finished water ice shall weigh not less than 6 pounds to the gallon.

Milk and Milk Products used in mix or frozen desserts shall include milk, cream, frozen cream, plastic cream, dried cream, butter, butter oil, fluid skim milk, sweetened and unsweetened evaporated milk, sweetened and unsweetened evaporated skim milk, sweetened and unsweetened condensed milk, sweetened and unsweetened condensed skim milk, superheated condensed milk, superheated condensed skim milk, dried whole milk, nonfat dried milk, sweet cream buttermilk, sweet cream condensed buttermilk, dried sweet cream buttermilk, or any of these products from which lactose has been wholly or partially removed after crystallization, and any other product made by the addition of a substance to milk, or to any of these milk products, mix or frozen dessert, and used for similar purposes, and designated as a frozen dessert by the health authority.

Ingredients Other Than Milk and Milk Products shall include wholesome fruits, flavorings, nuts, confectioneries, harmless coloring, stabilizers and emulsifiers.

Mix is the unfrozen combination of all ingredients of a frozen dessert with or without fruits, fruit juices, confectioneries, nut meats, flavor, or harmless color.

Confectionery shall mean candy, cakes, cookies, and glace fruits.

Pasteurization—The terms "pasteurization," "pasteurized," and similar terms shall be taken to refer to the process of heating, in approved and properly operated equipment, every particle of mix to one of the following minimum temperatures and holding at this temperature continuously for the specified time as indicated below:

155° F. and holding at such temperature for at least 30 minutes
175° F. and holding at such temperature for at least 25 seconds
194° F. using the "Vacreator" process

Provided, That nothing contained in this definition shall be construed as barring any other method or process, as may be demonstrated to be equally efficient and which is approved by the State health authority.

Frozen Desserts Processor is any person who freezes any pasteurized mix in semi-solid or solid form, for distribution or sale as a frozen dessert.

Frozen Desserts Manufacturer is any person who manufactures, pasteurizes, packages and/or freezes any mix for distribution or sale.

Frozen Desserts Distributor is any person who offers for sale or sells to another any frozen desserts for human consumption in a final package.

Frozen Desserts Mobile Unit shall mean any vehicle or temporary establishment that shall travel from place to place in which a frozen desserts processor freezes and/or packages frozen desserts.

Depot or Commissary for Frozen Desserts Mobile Units shall mean any place, premise or establishment in which pasteurized mix ingredients, containers, or supplies are prepared, or stored for the servicing of one or more mobile units and where facilities are provided for the cleaning of the vehicle and the cleaning and bactericidal treatment of the equipment and utensils.

Pasteurization of Mix

Every particle of the combined milk, cream, milk product or other ingredients used in the manufacture of a frozen dessert mix shall be heated and held at temperatures of not less than 155° F. for not less than 30 minutes; or 175° F. for not less than 25 seconds; or not less than 194° F. by the Vacreator process.

All temperature control instruments and devices used in connection with the pasteurization of mix and ingredients shall comply with the following or equally satisfactory temperature control and thermometer specifications. A high-temperature short-time pasteurizer may be adapted to pasteurize fluid milk and mix at different time and temperature requirements; Provided, That two separate temperature control systems be provided which will divert or stop the flow of product when the temperature is below the legal limit for the fluid milk or mix being pasteurized; Provided further, That when the pasteurization standard requires a change in both temperature and holding time, the method for changing the holding time shall be electrically interwired with the corresponding temperature control system in such a manner as to automatically provide the required time and temperature combination.

Maintenance of Pasteurization Temperature — Each high-temperature short-time system shall be equipped with dependable thermostatic controls, so designed and so set as to cause every particle of mix to be heated automatically to at least 175° F., and shall comply with the following: The control mechanism of the mix-flow control device shall be set and sealed, so that the forward flow of mix cannot start unless the temperature of the mix at the controller sensitizer be above 175° F., nor continue during descending temperatures when that temperature is below 175° F. The seal shall be applied by the health authority after test, and shall not be removed without immediately notifying the health authority. The system shall be so designed that no mix can be bypassed around the controller sensitizer, which shall not be removed from its proper position during the pasteurization process. The cut-in and cut-out mix temperatures as shown by the indicating thermometer shall be determined daily by the plant operator, and entered upon the recording thermometer chart monthly by the health authority.

Means shall be provided and used in pasteurization vats to keep the atmosphere above the mix at a temperature not less than 5° F. higher than the mix temperature during the heating and holding period. This requirement may be waived when 30-minute pasteurization is done at 160° F. or higher, provided an air-space thermometer be properly installed, and such thermometer indicates an air-space temperature of at least 160° F. throughout the holding period.

Specifications for Thermometers

The following are general specifications for thermometers except as indicated under specific type:

Type—except for recording thermometers, they are mercury-actuated, direct reading, contained in corrosive-resistant cases which protect against breakage and permit easy observation of column and scale; filling above mercury is nitrogen or equally suitable gas.

Magnification of Mercury Column—To apparent width of not less than 1/16 of an inch.

Scale—different for different type.

Accuracy—within 0.5° F., plus or minus, between different points. Test for temperature accuracy shall be made by the health authority upon installation, and at least monthly thereafter.

Submerged Stem Fittings—Pressure-tight seat against inside wall of holder, no threads exposed to mix.

Bulb—corning normal, or equally suitable thermometer glass.

Indicating Thermometers for Pasteurization Vats and Pockets

Type—as indicated above, reference line etched on tube at 155° F. with other markings permissible.

Magnification of Mercury Column—as indicated above.

Scale—Range of 130° F. to 210° F., extension on either side permitted; graduated in divisions of not more than 1° between 140° and 160° F., with not more than 16° per inch of scale; protected against damage at 220° F.

Accuracy—Within 0.5° F., plus or minus, between 154° and 157° F.

Submerged Stem Fittings—as indicated above.

Bulb—as indicated above.

Indicating Thermometers Located on Pasteurization Pipelines

Type—as indicated above; reference line etched at 155° F. and/or 175° F., and/or 194° F. or such other pasteurization temperature as is approved.

Magnification of Mercury Column—as indicated above.

Scale—Range not less than 20° F., including the pasteurization temperature plus or minus 5° F.; graduated in 0.5° F. divisions with not more than 8° F. per inch of scale.

Accuracy—as indicated above.

Bulb—as indicated above.

Air-Space Indicating Thermometers for Pasteurization Vats or Pockets

Type—as indicated above; bottom of bulk chamber not less than 2 inches, and not more than 3 1/2 inches, below underside of cover.

Magnification of Mercury Column—as indicated above.

Scale—Range of 130° F. to 210° F., extension on either side permitted; in not more than 1° divisions, with not more than 16° per inch of scale; protected against damage at 220° F.

Accuracy—Within 1° F., plus or minus, throughout the specified scale range.

Stem Fitting—as indicated above.

Bulb—as indicated above.

Recording Thermometers for Pasteurization Apparatus

Case—Moisture-proof under operating conditions in pasteurization plants.

Scale—Range of 145° to 165° F., in case of 25-second pasteurization, 145° to 200° F., with extension of scale on either side permitted; graduated in temperature-scale divisions of 1° spaced not less than 1/16 of an inch apart between 154° F., and 157° F., or, in the case of 25-second pasteurization, between 174° and 177° F. In the case of the Vacreator type of pasteurzation, temperature-scale division shall be of 1°, spaced not less than 1/16 of an inch apart between 193° and 196° F.

Temperature Accuracy—Within 1° F., plus or minus, between 154° and 157° F., or, in the case of 25-second pasteurization, between 174° and 177° F., and between 193° and 197° F. for use with a Vacreator. Temperature accuracy shall be tested by the health authority upon installation, and at least semiannually thereafter, and at such other times as the operator's daily check with the indicating thermometer may show the recording thermometer to be incorrect.

Time Accuracy—The recorded elapsed time, as indicated by the chart rotation, shall not exceed the true elapsed time, as shown by an accurate watch, over a period of at least

30 minutes at pasteurization temperature. All recorders, except those used as recorder-controllers for mix flow stops, shall be equipped with spring-operated or electrically-wound clocks. The time accuracy shall be tested by the health authority upon installation, and at least monthly thereafter, and entered upon the chart.

Pen-Arm Setting Device—Easily accessible; simple to adjust.

Pen and Chart Paper—Designed to give line not over 1/40 of an inch wide when in proper adjustment, easy to maintain.

Pressure System (Bulb, Tube, Spring, etc.)—Protected against damage at bulb temperature of 220° F.

Stem Fitting—Pressure-tight seat against inside wall of holder or pipe; no threads exposed to mix; location of seat in batch-type pasteurizers to conform to that of a 3-A Sanitary Standard wall-type fitting.

Chart Speed—The chart shall make one revolution in not more than 12 hours, and shall be graduated for a maximum record of 12 hours. The rotating chart-support shall be provided with a pin which will puncture the chart to prevent its fraudulent rotation.

Frozen Dessert Mobile Units

General requirements—All milk and milk products used in the manufacture of frozen desserts shall be of a quality and approved by the State Health authority. The processing, handling, and distribution of milk and milk products as well as the equipment, building, etc. used in the manufacture of frozen desserts shall conform to the minimum requirements for Grade A milk. In addition, mobile frozen dessert units shall comply with the following requirements:

(1) Each operator of a frozen dessert mobile unit shall obtain a "permit to operate" from the Health authority or his duly authorized representative.

(2) Truck interior shall be completely enclosed with the exception of serving windows and shall be of sufficient size with equipment and fixtures conveniently located so as to render efficient and sanitary operation.

(3) Serving openings shall not be larger than 18 inches wide and 28 inches high, and there shall not be more than two (2) serving openings to each mobile unit. The said serving openings shall be closed at all times that the operator of the mobile unit is not actually dis-dispensing frozen desserts.

(4) A potable water supply tank, minimum capacity of forty (40) gallons, heated electrically or otherwise, and tilted toward a capped drain cock, shall be provided. Water inlet pipe shall be of removable flexible copper or other approved tubing with nozzle for hose connection capped when not being used. The tank shall be provided with permanent vacuum breaker properly mounted (6" above top of tank). Tank shall be vented and screened with copper, brass or bronze screen. Hose and rack for connection to potable water supply shall be provided.

(5) A double compartment seamless sink supplied with running hot and cold water, equipped with a swivel faucet, shall be provided. Each compartment shall be large enough to accommodate the largest piece of equipment to be cleansed therein. Said sink shall be trapped and vented.

(6) A hand sink, seamless, with running hot and cold water, soap and single service or individual towels, or mechanical hand dryer shall be provided. Said sink shall be trapped and vented.

(7) A suitable waste tank with capacity of at least equal to the water supply tank, shall be provided, tilted toward a drain cock with an adequate method of gauging the contents. It shall be emptied and flushed as often as necessary, and in a sanitary manner in order to maintain sanitary conditions.

(8) A refrigerator box of ample capacity, constructed of stainless steel or other non-corrosive material and equipped with an indicating thermometer shall be provided. The floor shall be pitched towards the center drain. Metal racks or platforms shall be provided to store all ingredients.

(9) Floors of the mobile unit shall be of metal or similar approved material. Junctures of floor, wall and adjoining fixtures shall be watertight and covered. The floors shall be kept clean and dry at all times during the operation of the mobile unit.

(10) Frozen dessert mix shall be mechanically packaged in containers approved by the health authority or his duly authorized representative.

(11) A refuse can with cover and a waste can or container for deposit of cups, napkins, etc., by customers must be installed which shall be of sufficient size for daily needs, so constructed, designed and placed so they can be readily cleaned and kept clean, so located as not to create a nuisance, and so labeled that the public will be informed.

(12) The truck interiors shall be provided with artificial light sufficient to provide fifteen (15) foot candles of light in all areas.

(13) Separation by partition (self-closing doors accepted) shall be made between driver's seat and manufacturing unit unless vehicle be air-conditioned.

(14) Persons handling frozen desserts or engaged in manufacture thereof shall be clothed in white, clean, washable uniforms, and shall wear a white cap which shall be washed or discarded when soiled, but in no event less frequently than daily.

(15) The original frozen dessert permit to operate shall be displayed on each vehicle with photostat posted in operator's depot.

(16) Each mobile unit shall display a sign advising the public of the type of frozen dessert being sold (Ice Milk, Ice Cream). This sign shall be printed in letters at least 8" in height.

Depots for Frozen Dessert Mobile Units

All mobile units shall operate from a depot and shall report to their respective depot for cleaning and sanitizing at least once each day. All depots shall comply with the following requirements:

(1) Structurally, the building shall comply with the sanitary requirements of the area.

(2) For washing purposes, there must be at least two large sinks, each of which must be large enough to accommodate the largest piece of equipment to be washed. Sinks are to be provided with drain-boards of impervious material.

(3) A metal pipe drying rack for utensils shall be provided.

(4) Clothes lockers and garbage cans shall be provided.

(5) Adequate storage for perishable materials shall be provided.

(6) A separate room shall be provided for the storage of all non-perishable food and paper products.

(7) Adequate facilities shall be provided for the washing of vehicles.

(8) All plans and specifications for depots shall be approved by the health authority or his duly authorized representative prior to construction of same.

Possible Guide for Grading Frozen Desserts Plants

Since no grading, nor bacterial count system has been recommended in recent regulatory recommendations by the Public Health Service, the 1940 recommendations are given below merely as a guide:

Alternative Bacterial Standards for Frozen Desserts, Pasteurized Mix, and Ingredients Derived from Milk

Product, heated or unheated, grade of plant[11]	Log. average plate count not to exceed	Log. average direct microscopic count not to exceed		Arithmetic average reductase hours not less than
		Clumps	Individual Organisms	
	Frozen Desserts and Pasteurized Milk			
Grade A plants	50,000	-	-	-
Grade B plants	100,000	-	-	-
Grade C plants	No limit	-	-	-
If pasteurized:	Cream as Ingredient			
Grade A plants	100,000	-	-	-
Grade B plants	500,000	-	-	-
Grade C plants	No limit	-	-	-
If raw:				
Grade A plants	400,000	400,000	1,600,000	5
Grade B plants	2,000,000	2,000,000	8,000,000	2 1/2
Grade C plants	No limit	No limit	No limit	
If pasteurized, condensed, powdered, etc.	Milk and Ingredients Derived from Milk			
Grade A plants	50,000	-	-	-
Grade B plants	250,000	-	-	-
Grade C plants	No limit	-	-	-
If raw				
Grade A plants	200,000	200,000	800,000	6
Grade B plants	2,000,000	1,000,000	4,000,000	3 1/2
Grade C plants	No limit	No limit	No limit	No limit

11. The grade A specifications listed here are identical with the minimum requirements in the non-grading form of this ordinance.

Chapter XIX

Food and Drug Control

The recognition that food may cause sickness and death goes back to the earliest period of recorded history. Experience taught man that certain naturally occuring plants always produced illness when eaten. These were long ago eliminated from the eating habits of mankind. They also learned that certain animal foods produced illness during certain seasons. These they also guarded themselves against. That certain naturally occurring acceptable foods sometimes caused illness was also known early in man's history, but the reasons why this happened did not come to light until the germ theory of disease was demonstrated and became an acceptable fact. This was scarcely more than three quarters of a century ago. Most of the precise knowledge about food-borne poisons and food-borne infections are of relatively recent discovery, and even today much is yet to be known about this subject. As far as our knowledge extends at present, we recognize only a few fundamental causes for the fouling of food, although the circumstances in which these fundamentals operate are innumerable, most of which relate to the handling of food. For example, one fundamental cause of fouling is bacterial contamination, but such contamination may take place in any number of circumstances associated with the handling of food in the process of production, preservation, storage, distribution, and preparation for consumption.

The primary causes of food fouling are:

1) Parasitic contamination of food, such as by bacteria;
2) Autolysis, or spontaneous disintegration of food by enzyme action;
3) Adulteration of food with unsalubrious materials.

Sanitary Production and Preservation.

Since every step in the handling of food may be a circumstance in which fouling may occur, the sanitarian must train himself to visualize every minute movement of the handlers of food, the design and mechanism of every tool and machine associated with the handling, the techniques and processes carried on, and the nature of the food itself. Besides this, the sanitarian should know whence the raw food itself came, the sanitary history of the locality, and the sanitary history of the food handlers and their families so far as communicable diseases are concerned. For example, he should ask himself:

Whether diseases such as typhoid fever, tuberculosis, brucellosis, scarlet fever, etc. are prevalent in the locality;

Whether any communicable disease capable of spread by food exists among the food handlers or their families;

Whether carriers of such diseases exist;

The sources of water supply and methods of feces and other waste disposal;

The sanitary conditions of the buildings where food is being produced;

The technique of cleaning, heating, cooling, preserving, packing, canning, bottling, storage and other processes;

Whether breaks in the approved technique occur due to poor tools, machine or inefficiency of the workmen;

Whether part of the food material is separated from the food, or other materials are added to give extra bulk, better color, or longer preservation;

Whether the food is of good quality before processing.

Many other questions could be entertained about production, processing and distribution of foods. In the case of fresh vegetables or fruits, one should not forget to inquire whether the land where they are grown is fertilized with human excreta or whether insecticides poisonous to man are used to control insect pests. In case of meats, one should not forget to examine for preservatives, and attempt to become acquainted with the slaughter houses if they be locally situated.

It cannot be too strongly emphasized that in the vast majority of outbreaks of food-borne sickness, the food affected is not noticeably altered in appearance, taste, or smell, yet the sanitarian must know the appearance, taste, and odor of fouled food to the extent that this be possible.

Table 1

Division of Environmental Engineering
and Food Protection
Milk and Food Branch

Public Health Service
Washington, D. C.

Summary of Disease Outbreaks Conveyed Through Foods Other Than Milk and Milk Products Reported as Having Occurred in the United States During the Years 1938-1966, Inclusive [1]

	Botulism			Chemical Food Poisoning			Dysentery			Food Infection, Food Poisoning, & Gastroenteritis			Scarlet Fever & Septic Sore Throat			Trichinosis			Typhoid Fever & Other Salmonella Infections			Miscellaneous and Unknown			Total - All Diseases		
Year	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths	Outbreaks	Cases	Deaths
1938	5	11	6	0	0	0	3	118	0	39	1,665	3	0	0	0	3	14	0	20	439	16	0	0	0	70	2,247	25
1939	9	16	7	0	0	0	2	99	0	117	3,038	2	1	27	0	2	18	0	12	475	2	3	97	1	146	3,770	12
1940	5	17	8	2	9	0	4	318	0	163	4,443	4	0	0	0	16	116	5	27	676	13	1	9	0	218	5,588	30
1941	6	20	12	5	78	14	6	443	3	167	4,859	4	1	96	0	9	98	9	29	476	11	0	0	0	223	6,070	53
1942	7	20	10	8	509	52	2	90	6	190	9,690	10	0	0	0	9	52	2	28	1,056	21	1	3	0	245	11,420	101
1943	4	10	7	3	54	0	7	1,029	4	237	11,258	5	2	133	0	4	49	1	28	1,405	16	0	0	0	285	13,938	33
1944	9	29	19	8	105	5	7	939	5	235	11,243	8	1	1,200	0	7	66	3	28	889	5	3	87	0	298	14,558	45
1945	12	36	21	6	34	0	3	292	0	214	9,637	11	1	46	0	4	193	1	31	744	16	5	565	8	276	11,547	57
1946	7	15	9	10	1,484	0	1	40	5	244	8,684	2	4	768	0	5	25	1	27	1,210	0	1	300	0	299	12,526	17
1947	12	31	18	6	1,047	0	3	72	1	266	10,568	7	0	0	0	3	53	0	23	670	3	3	95	0	316	12,536	29
1948	7	30	6	5	74	1	1	120	0	270	8,304	6	1	270	0	14	94	1	23	558	2	6	512	1	327	9,962	17
1949	4	34	6	5	31	0	4	87	0	325	7,782	4	1	84	0	10	77	0	16	890	1	2	58	0	367	9,043	11
1950	3	6	2	4	21	0	1	15	0	310	8,930	2	0	0	0	4	14	0	21	1,173	0	4	15	1	347	10,174	5
1951	9	20	12	6	31	0	0	0	0	211	5,896	2	1	150	0	7	32	0	15	867	0	5	186	0	254	7,182	14
1952	4	12	4	0	0	0	5	349	0	110	5,706	0	1	82	0	5	40	0	19	644	3	1	2	0	145	6,835	7
1953	7	10	5	4	144	1	7	1,299	0	143	7,762	1	1	95	0	13	134	0	19	470	2	0	0	0	194	9,914	9
1954	7	16	7	3	182	0	8	881	0	185	9,447	0	0	0	0	6	53	3	26	1,238	2	0	0	0	235	11,817	12
1955	5	14	7	5	99	2	2	60	0	157	8,471	0	1	119	0	5	92	0	17	765	0	1	13	0	193	9,633	9
1956	11	22	9	7	147	1	0	0	0	158	9,134	2	4	70	0	11	98	1	19	1,662	3	0	0	0	210	11,133	16
1957	6	12	4	4	50	0	5	268	2	197	8,507	1	1	600	0	3	14	3	34	1,634	0	0	0	0	250	11,085	10
1958	3	4	0	12	148	0	1	19	0	190	8,720	0	0	0	0	7	68	0	23	966	4	0	0	0	236	9,925	4
1959	10	24	7	13	71	1	0	0	0	274	9,036	0	0	0	0	6	38	0	19	1,426	0	0	0	0	322	10,595	8
1960	4	7	5	11	93	3	5	811	0	136	4,701	5	1	954	0	2	3	0	18	659	0	5	206	0	182	7,434	13
Total - 1938-1960	156	416	191	127	4,411	80	77	7,349	26	4,538	177,481	79	22	4,694	0	155	1,441	30	522[2]	20,992[2]	120[2]	41	2,148	11	5,638	218,932	537
1966 [3]	7	16		4	182		3	77		48	3,182					3	7		26	1,547		84	3,138		175	8,150	

[1] Data for years 1950-1959 from Summaries of Disease Outbreaks prepared by Dauer, Sylvester, and Davids, National Office of Vital Statistics, and published annually in the Public Health Reports.
Data for 1960 from "1960 Summary of Disease Outbreaks and a 10-Year Résumé" by Dr. Carl C. Dauer, National Center for Health Statistics, Public Health Service.

[2] Of these totals, 122 outbreaks, 1,491 cases, and 91 deaths were attributed to typhoid fever.

[3] Data added

Food-borne Diseases

Food-borne diseases include a number of illnesses among which a group known as food poisoning is most commonly associated in the public's mind. In the earlier history of the study of food-borne illness, the term ptomaine poisoning was used. Such a designation is, however, both unscientific and incorrect. The term food poisoning better describes this group of illnesses, but is somewhat vague and limited. It has been defined to include illnesses associated with explosive occurrence of intestinal upset resulting from the ingestion of food containing certain chemical poisons, poisons derived from animals and plants, toxic products of several types of bacteria, and infections caused by several types of bacteria. There are a number of reasons why the designation of food poisoning is unsatisfactory, particularly because some of the illnesses in this group are, as far as can be ascertained, not the result of poisons or toxins but due to direct bacterial irritation of the intestinal tract, and because other illness of the diarrheal and dysentary nature have not been included in this designation although they appear to belong here. Therefore the following classification of food-borne diseases is offered:

A. Food-borne Intoxications:
   1. Food-borne chemical poisoning.
   2. Plant and animal food-borne poisoning.
   3. Food-borne bacterial poisoning.
      a) Staphylococcic,
      b) Botulism.

B. Food-borne Infections:
   a) Salmonellosis:
      1) paratyphoid,
      2) typhoid.
   b) Streptococcic.
   c) Shigellosis.
   d) Amebiasis.
   e) Non-specific diarrheas.
   f) Others: Tuberculosis, brucellosis, hemorrhagic jaundice, etc.
   4. Food-borne helminthiasis:
      a) Tapeworm.
      b) Trichinosis.
      c) Roundworm.
      d) Flukes.

The putrefaction of food must not be associated with food poisoning. Putrefactive foods, as for example, limberger and camembert cheeses, are not poisonous. It is important to distinguish between beneficial bacterial action on foods and dangerous bacterial actions on foods. Decomposition is usually the result of bacterial action, but it may take place also as a result of the natural enzyme process (autolysis) in food. Some types of decomposition are objectionable as for example an old egg, but in some instances decomposition renders food more tender and improves the flavor. Some people prefer highly decomposed or gamey meat. Bread, cheese, buttermilk, sauerkraut, vinegar, cider and many other foods are decomposition products of yeast fermentation or bacterial action or a combination of both which produce definite changes in the particular food. Autolytic decomposition per se is generally not harmful to health. Decomposition that takes place in the presence of contaminating bacteria is to be avoided, not because of the decomposition but because the bacteria may be pathogenic or may produce toxins which cause disease. Such foods may, however, not show any signs of danger, but may actually appear appetizing.

When an outbreak of food-borne bacterial poison occurs it should be immediately investigated if the true cause be established. A delay of hours after vomiting and diarrhea have occurred may mean that the ingested toxins have been discarded in the vomitus and excreta. If none of the original food be left, it may be difficult to identify the specific causative agent. In an outbreak of food-borne bacterial infection, a delay of hours may often bring about marked bacterial changes in perishable products which were not present at the time of consumption. From a legal standpoint, a prompt and intelligent investigation may prevent unnecessary litigation expense and afford the basis of a just settlement if settlement appears warranted. It is generally important to ascertain in so far as possible what items of food had been eaten at previous meals for a period

of 48 hours. When a large number of cases occur within as short a period as 2 to 3 hours after partaking of food, attention should be centered particularly on the last meal and on any food eaten by all or a majority of the persons afflicted. When the onset of symptoms in different individuals appears over a period of many hours, it is important to know the items of food in the diet for several meals past. If the outbreak involves persons who have shared in a particular meal or eaten at a particular place, it is a good plan to prepare a list of the various items of food served and check these items with persons who ate the meal or who ate at the place in question. Frequently a single item may be found to be the common denominator for those who are made ill. If this fact be observed, much time may be saved by making a laboratory examination directly on the incriminated item of food. Usually not every individual will be made ill when a specific item is involved. Such variables as the amount eaten (dosage), and individual resistance play an important part. Generally, however, the majority of people partaking of the involved food will be affected when such an outbreak occurs. Sometimes psychic disturbances account for symptoms in some individuals who are present during the illness of others but who have not eaten the incriminated food. If too long a time elapses before the investigation is started, the data obtained is less reliable, since most people find it difficult to remember what they have eaten at previous meals or whether they experienced any symptoms at the time in question. It must also be remembered that, when samples of food are sent to the laboratory, data concerning the interval between swallowing the food and the onset of symptoms of the ilness be stated, since this information gives direction to the course of the laboratory work.

The principal causes of food-borne disease outbreaks are listed below. Each factor depends on the human operational element. Not only is each factor important as a general area, but it is vitally important that the sanitarian pinpoint, where possible, the specific operational situation or circumstance within each area that may be critical for opidemiological control.

1. Failure to refrigerate perishable foods; 2. Diseased employees; 3. Poor personal hygiene; 4. Failure to thoroughly cook contaminated foods; 5. Obtaining food from unsafe sources; 6. Failure to clean and disinfect kitchen utensils and equipment; 7. Poor food storage practices leading to contamination by rodents, sewage, customers, and admixture with toxic materials.

Procedure for The Investigation of Foodborne Disease (Recommended by the International Association of Milk and Food Sanitarians, Inc. 1957)

1. Visit the establishment or establishments where the suspected meal, meals, or drinks were prepared and consumed, and make a complete inspection. As a part of this inspection, fill out form "Food Preparation and Sanitation Report." (Figure 1).

a. Secure a copy of the menu for the day or meals.

b. Inquire from the cook, proprietor, and others as to the source and method of preparation of each item of food shown on menu.

c. Inquire as to the method of storage of all perishable foods — poultry, meats, salad dressings, broths, dairy products, etc., before and after cooking.

d. Determine where the establishment purchased various foods served at the suspected meal, (i.e., the retailer, wholesaler, distributor, canner, processor, manufacturer, or producer).

e. Make inquiries regarding the health of food-service employees in the establishment. A simple inquiry regarding the health of food-service employees is often not sufficient for the epidemiological investigation of certain enteric infections, such as typhoid fever and dysentery. Since organisms which cause food-borne disease may be found in respiratory and skin infections, physical examination of the employees, including laboratory tests, may be indicated. It is important to remember that the food may have been merely the vehicle for dissemination of pathogenic micro-organisms, the actual source being a carrier who can be identified only by stool, nose or throat cultures.

f. Obtain the assistance of the health officer or a physician to determine the cause, if food-service employees have been away from work because of recent illness.

g. Note any employees who have infections on hands or other exposed surfaces of their bodies.

h. Make a complete sanitary inspection of the establishment, including a determination for toxic metals, such as cadmium, antimony, zinc, and copper in the equipment, and the presence of poisonous pesticides and cleaning agents on the premises (if such subtances be found, investigate the possibility of their having contaminated food.)

i. If there be evidence of the presence of insects or rodents, determine whether or not they have had access to the food involved.

2. Visit all persons known to be or suspected of having been present at the time the questioned meal was eaten. This would include those who prepared, served, or ate the meal. During these interviews, fill out a "Case History Questionnaire" (Figure 2) as completely as possible, using a separate form for each person interviewed. Do not suggest answers to the questions, but permit the patient or person to answer the questions to the best of his ability. All the different types of foods eaten by the persons involved over a period of 48 hours preceding onset of symptoms should be listed, if possible. In an outbreak of typhoid fever, the offending meal may have been consumed 7 to 21 days prior to onset of symptoms.

3. If patients to be visited be hospitalized, or are being treated by a physician, obtain information relative to symptoms, available laboratory findings, diagnosis, and treatment from the physician, and include the information in the case history.

4. Samples of all perishable leftover foods served at the suspected meal or meals, including water samples, should be taken aseptically and kept under refrigeration. The correct procedure for collecting these samples should be followed, and the "Sample Collection Report" should be completed (Figure 3).

5. In some instances, carbon monoxide from improperly ventilated heaters, gas refrigerators, and similar appliances may be the cause of the illness. Therefore, if reported illnesses be confined to members of one household or employees of one establishment, a check for faulty gas appliances is suggested.

6. Correlate, on a "Summary of Case Histories" form (Figure 4), the information obtained from patients and others interviewed and from the place where the suspected meal was served.

The fact that one food was consumed by all persons who attended the meal is not conconclusive evidence. It is necessary to determine, also, how many of those not attacked ate each food item. The determination of which food was the vehicle requires a comparison of the percentage of persons who ate the food without becoming ill with the percentage of those who were ill. In making this comparison, a tabulation by food items, as shown below would be helpful.

Table 2. Correlating Tabulation of Persons who Ate and Did not Eat Various Foods, and Those who Became Ill and Did not Become Ill, and the Attack Rates

	Group 1 PERSONS WHO ATE SPECIFIED FOOD				Group 2 PERSONS WHO DID NOT EAT SPECIFIED FOOD			
	Total	Ill	Well	Attack Rate	Total	Ill	Well	Attack Rate
Baked Ham	46	29	17	.63	29	17	12	.59
Spinach	43	26	17	.60	32	28	12	.62
M. Potatoes	37	23	14	.62	38	23	15	.61
Cabbage Salad	28	18	10	.64	47	28	19	.59
Jello	23	16	7	.66	52	30	22	.58

Rolls	37	21	16	.57	38	25	13	.66
Br. Bread	27	18	9	.67	48	28	20	.58
Milk	4	2	2	.50	71	44	27	.62
Coffee	31	19	12	.61	44	27	17	.61
Water	24	13	11	.55	51	33	18	.65
Cokes	40	27	13	.67	35	19	16	.54
Vanilla Ice Cream	54	43	11	.80	21	3	18	.14
Chocolate Ice Cream	47	25	22	.53	28	21	7	.75
Fruit Salad	6	4	2	.67	69	42	27	.61

The responsible food should have a very high figure for Group 1 and a much lower one for Group 2. If the date be complete and accurate, and if proper samples of the particular food have been secured and prepared according to directions, the laboratory analysis may confirm the findings.

It must be pointed out that, in preparing this summary, discrepancies in the statements made by various patients may be observed, in which case it may be necessary to interview some of the patients a second time.

Food-borne Chemical Poisoning: In general,food-borne chemical poisoning is characterized by a short interval of time, varying from 10 minutes to 2 hours, elapsing between the swallowing of the poisonous food and the onset of symptoms. The history of the outbreak may suggest the specific chemical. For example, antimony poisoning has occurred from eating foods cooked in cheap, gray-enameled cooking utensils; cadmium poisoning is usually associated with acid liquids such as lemonade in cadmium-plated metal utensils; sodium fluoride should be thought of if this insecticide be used in the kitchen; lead and arsenic poisoning should be considered where sprays have been used on foods such as fruits. (See Table 5)

Plants and Animals Food-borne Poisoning: About 518 species of fish involving 95 families have been incriminated as poisonous, 38 being of commerical importance. Some of the poisonous fish are the puffer, fugu or blowfish, toado, globe fish, the ciguatera group, moray eel, the scomboid group (tuna, mackerel, bonito, albacore, and skipjack), great blue shark, smooth dogfish, angel shark, Greenland shark, and fresh-water minnows. Mussel poisoning is suggested if mussels from the Pacific Coast be eaten at certain seasons of the year. A variety of common clams may also be so affected as may any plankton feeder. Asari (Venerupis semidecussata) and oyster (Ostrea gigas) poisoning in Japan is different from mussel poisoning. The poison is not destroyed by boiling for 3 hours. Favism would be associated with eating the fava bean or being around these plants when they are in blossom. Snakeroot poisoning is usually accompanied by a history of drinking milk from cows pastured in wooded areas where snakeroot is abundant. Mushroom poisoning occurs from eating poisonous varieties of this plant. Ergotism is rare in this country but is associated with eating meal or bread from rye contaminated with the fungus, Claviceps purpurea. Water-hemlock poisoning is rare but occurs when leaves (called wild parsnip) or roots (called wild carrots) of this plant are eaten by mistake. Honey has been implicated in poisoning and has been associated with specific flowers, such as varieties of azalea, rhododendrum, oleander, and perhaps mountain laurel and palmetto, from which bees gather nectar. Honey from flowers of the black locust has at times been toxic. The toxin is referred to as "andromedotoxin." It is soluble in water to a degree. Boiling in water does not destroy it. Akee poisoning is caused by eating the fruit of the akee tree (Blighia sapida) which is valued as a rich protein food in tropical America, southern Florida, and Jamaica. The poison (probably a glucoside) is present in the seeds and pods of both ripe and unripe fruit. The toxic principle is water soluble and heat stable. Tung-nut poisoning is from the nut of the tung-nut tree (Aleurites fordu, A. moluccana, A. trisperma, and A. montana). Rhubarb leaves used as a substitute for greens have caused many cases of oxalate poisoning. (See table 6)

Figure 1

Food Preparation and Sanitation Report
(Foodborne Disease Outbreak)

1. Outbreak at (*Name and Address of establishment*)			Date of outbreak	Time of suspected meal
Day and Hour of onset	**First case**	**Last case**	**Number persons exposed**	**Number persons ill**

2. Food history

Food item	Source	Preparation of item			Storage and Refrigeration	Results of laboratory examinations
		When?	Where?	By Whom?		

3. Canned foods (If commercially prepared, identify manufacturer, brand and lot number. If home canned, describe process used):

4. History of food handlers:

Name	How long employed here?	Duties	History of recent illness	Laboratory examination

5. Epidemiologic conclusions:

a. Suspected (or confirmed) food items:
b. Causative Agent:
c. How was food contaminated:

Date investigation begun	Date of this report	Name(s) of Investigator(s)

Note: Completed regular inspection form and narrative report should be attached.

Figure 2

Case History Questionnaire

City	State
Name of Person	Address

Occupation	Age	Sex	Telephone No.

Did individual partake of the suspected meal? ☐ yes ☐ no
If yes, date and hour food eaten:
Did individual become ill? ☐ yes ☐ no
If yes, date and hour of onset:
Below is a list of foods and beverages served at the suspect meal (check only those which were eaten).

Food Item		Food Item		Food Item	

Which of the following symptoms did individual have, and how long (in hours) did they last?

Nausea or Vomiting ..... Diarrhea ..... Fever .....
Prostration ..... Paralysis ..... Other .....

Was a physician consulted? ☐ yes ☐ no Diagnosis:

If yes, physician's name and address:

Name of hospital, if hospitalized:

Names of other persons who partook of the suspect meal:

Date ..... Investigator .....

Figure 3

Sample Collection Report

Date	City	Sample Number

Description of sample and source:

Identifying marks on seal (e.g., code or lot number)

Name of person from whom sample collected

Name and address of establishment where collected

Name of dealer, manufacturer, or processor, if known

Analysis requested (chemical, bacterial, etc.)

Method of sterilizing container:

Method of sterilizing utensils used to collect samples

Other suspected foods:

Method of shipping sample (air, rail, etc.)

Investigator .....

Laboratory results:

Date of laboratory report ..... Laboratory Investigator .....

Name and address of laboratory

Figure 4

Summary of Case Histories

Location of Outbreak (*Name and Address of Establishment*) | Date of Outbreak

Names of persons (sick or well) who ate suspected food or drink	Age	Ill (yes or no)	Required medical aid (yes or no)	Date and hour food eaten	Date and hour of onset	Food served at suspected meal (Check foods eaten)								Symptoms					
														Nausea or Vomiting	Diarrhea	Fever	Prostration	Paralysis	Other

Suspected Food or Foods (*Include origin of each food item*):

Date of Report:..... Investigator: .....

Table 3

Disease outbreaks conveyed through foods other than milk and milk products in the United States in 1940 and 1941 as reported by State health authorities, by kind of food.

Kind of Food	1940		1941	
	Outbreaks	Cases	Outbreaks	Cases
Fish	9	274	1	11
Fowl, fowl and dressing, fowl and gravy	12	968	20	826
Fruits and vegetables	5	53	4	135
Ham, pretreated*	7	45	3	17
Ham, smoked	21	392	23	529
Home-canned fruits, juices and vegetables	5	17	5	17
Meat and meat products other than pork and pork products	19	755	11	345
Pies and pastries, cream-filled	37	400	47	841
Pies and pastries other than cream-filled	5	65	12	204
Pork and pork products other than smoked and pretreated ham*	22	134	15	217
Puddings	4	93	3	106
Salads	4	213	15	453
Sandwiches	10	243	10	403
Sauces, salad dressings, and gravy	6	378	3	55
Shellfish	5	118	10	301
Combined foods	7	620	9	451
Miscellaneous	6	20	8	359
Undetermined	34	800	24	800
Total	218	5,588	223	6,070

*"Pretreated" denotes special processing to make the ham more tender, as by heat or enzyme treatment.

Table 4

Disease outbreaks conveyed through milk and milk products in the United States in 1940 and 1941 as reported by State health authorities, by kind of product.*

Kind of product	1940		1941	
	Outbreaks	Cases	Outbreaks	Cases
Buttermilk, raw	2	18	0	0
Canned milk	0	0	1	4
Cheese curds, raw	0	0	1	19
Cheese, undesignated	0	0	1	?
Cottage cheese, undesignated	1	6	0	0
Frozen desserts, pasteurized	0	0	1	3
Ice cream, raw	2	84	2	16
Ice cream, pasteurized	1	229	3	59
Ice cream, undesignated	2	8	1	6
Sherbet, undesignated	0	0	1	5
Sweet milk, raw	32	1277	18	531
Sweet milk, pasteurized	1	47	6	229
Sweet milk, undesignated	1	5	0	0
Sweet milk and sweet cream, raw	1	4	1	77
Sweet milk or chocolate milk	0	0	1	100
Total	43	1678	37	1049

*Six of these outbreaks were reported as possibly due to milk and milk products.

Food-borne Bacterial Poisoning: This source is responsible for the majority of outbreaks of food poisoning. The foods involved are usually those in which the causative microorganism can grow. The concept that spoiled meat is a most common cause of food-borne bacterial poisoning in the United States is not well founded and should be entertained cautiously. Canned foods are too frequently singled out as a cause of this type of illness without any just reason. However, meat and canned foods should not be exempted from consideration and examination, along with other food items, in any investigation of an outbreak.

Botulism and staphylococcus food-borne poisoning result from eating food in which these organisms have grown and produced toxins. The symptoms are due entirely to preformed toxins and not living bacteria.

TABLE 5 FOOD-BORNE INTOXICATIONS OF INORGANIC AND SYNTHETIC CHEMICAL ORIGIN

Disease	Specific Agent	Foods Usually Involved	Signs and Symptoms	Incubation Period
Antimony Poisoning	Enamelware (Gray)	Leaching of container by acid foods.	Vomiting, abdominal pains, spasms, collapse.	Few minutes to hours.
Arsenic poisoning	Insecticides and rodenticides.	Any foods accidentally contaminated.	Vomiting, diarrhea (depending on dose).	1 hour or less.
Cadmium poisoning	Plating metal	Leaching of containers and trays by acid foods including fruit juices.	Nausea, vomiting, cramps.	1/2 hour or less.
Copper poisoning	Copper containers	Accidental contamination and leaching of containers by acid foods.	Vomiting, no specific symptoms.	6 - 8 hours.
Cyanide poisoning	Silver polish containing cyanide	Any food accidentally contaminated.	Nausea, vomiting, diarrhea, cold perspiration, exhaustion.	1/2 to 6 hours.
Fluoride poisoning	Insecticides containing sodium fluoride.	Accidental contamination, such as mistaking the powder for baking powder, soda or flour.	Vomiting, retching, cramps, pallor, diarrhea, muscle spasm, convulsions, collapse.	1 hr. or less.
Lead poisoning	Pesticides	Accidental contamination, or fruits and vegetables sprayed with pesticides.	Abdominal pains, vomiting, diarrhea.	1/2 hour or longer.
Zinc poisoning	Galvanized ware	Accidental contamination; leaching of galvanized containers by acid foods, such as apples and rhubarb.	Diarrhea, astringent taste, pain in mouth and throat.	1 hour or less.
Methyl chloride poisoning	Leaking mechanical refrigerators	None, but may simulate food poisoning such as botulism.	Progressive drowsiness, mental confusion, stupor, weakness, nausea, abdominal pain, vomiting, convulsions, cyanosis coma.	Variable
Chlorinated hydrocarbon poisoning	Insecticides	Accidental contamination of food by spraying.	Nausea, vomiting, malaise, dizziness, tremors, convulsions.	30 min. to 4 hours or more.
Organophosphorus compound poisoning	Insecticides	Accidental contamination of food by spraying.	Sweating, salivation, increased bronchial secretion, vomiting, colic, diarrhea, blurred vision, slow pulse, muscle tremor, cramps, paralysis, convulsions.	30 min. to several hours.
Carbon monoxide poisoning	While carbon monoxide poisoning is not attributable to food, it sometimes causes illness that may be confused with food intoxication. Thus, it should be considered when ilnesses that are suspected as being due to foods are being investigated.			

Table 6 FOOD-BORNE INTOXICATIONS OF PLANT AND ANIMAL ORIGIN

Disease	Specific Agent	Food Usually Involved	Signs and Symptoms	Incubation Period
Castor Bean poisoning	Ricin (a toxin in the castor bean).	Castor bean	Colic, thirst, vomiting, diarrhea, cold sweat, collapse.	Few days
Ergotism	Parasitic fungus of rye (Claviceps purpurea)	Rye meal or bread	Gangrene, involves limbs, especially fingers, toes, occasionally ears and nose; convulsive depression, weakness and drowsiness, headache, giddiness, painful cramps in limbs and itching of skin.	Gradual, usually after several meals of diseased rye in meal or bread.
Favism	Bean (Vicia fava) or inhalation of pollen from blossoming plant	The fava bean	Acute febrile anemia, with jaundice, hematuria, and hemoglobinuria.	About one day after ingestion; 2 to 6 hours after inhalation of pollen.
Mushroom poisoning	Toxins (Phalloidine and other alkaloids) of certain species of mushrooms.	Poisonous mushrooms (usually Amanita phalloides and A. muscaria)	Salivation; sudden severe abdominal pain, intense thirst; nausea, retching; vomiting; profuse watery stools; excessive perspiration; a flow of tears.	15 min. to 15 hours.
Rhubarb leaves poisoning	Oxalic acid	Rhubarb leaves	Stomach pain, diarrhea, vomiting, thirst, tetanic convulsions.	Variable, from a few minutes to many hours, depending upon dose of oxalic acid.
Selenium poisoning	Selenium	Milk, eggs, meat, vegetables, and cereal grains produced in seleniferous regions.	Dermatitis, skin rash, fatigue, dizziness, sleepiness, depression, dullness, jaundice.	Unknown.
Shellfish poisoning	A thermostable alkaloid contained in plankton (Gonyaulax catenella) consumed by shellfish.	Mussels and clams (especially during certain seasons of the year.)	Respiratory paralysis; milder symptoms consist of trembling lips to a complete loss of power in the muscles of extremities and neck.	5 - 30 minutes or longer.
Snakeroot poisoning	Tremetol from snakeroot (Eupatorium urticaefolium)	Milk from cows pastured on snakeroot.	Weakness or prostration; vomiting; severe constipation; stomach pain.	Variable period; after repeated use of milk from cows pastured in an area in which snakeroot is present.
Solanine (Potato) poisoning	Solanine tuberosum	Green, sprouting, or sunburned potatoes, wild celery.	Vomiting, diarrhea, headache, abdominal pains, prostration, circulatory collapse, stupor, convulsion.	Few hours.
Water hemlock poisoning	Cicutoxin or resin from water hemlock (Cicuta maculata).	Leaves and root of water hemlock.	Nausea, vomiting, convulsions.	1 to 2 hours.

	1. Tetraodontoxin in liver and ovaries	"Blowfish," fugu, globefish, toado, puffer	Numbness and tingling of lips, tongue, fingers, and toes; loss of taste, respiratory paralysis in fatal cases; nausea, vomiting, abdominal pain, and ataxia is usually present.	30 minutes to several hours.
	2. Ciguatera toxin	Snapper	Epigastric pain, numbness in limbs, tingling about face, giddiness, watery stools, slow pulse, contracted pupils; tingling sensation over whole body, especially lips and fingers, ataxia, myalgia, muscular weakness.	Few minutes to 30 hours.
Fish Poisoning (ichthyosarcotoxism)	3. Gymnothorax toxin	Gymnothorax Moray eel (G. buroensis, G. flavimarginatus, G. jaranicus, G. meleagris, G. petelli, G. pictus, G. undulatus)	Tingling and numb sensation about lips, vomiting, coma, perspiration, nausea, aphonia, foaming at mouth, convulsions, respiratory paralysis.	20 minutes to 7-8 hours.
	4. Scombroid toxin	Fish of genera Euthynnus and Katsuwonus	Nausea, vomiting, redness and flushing of face, engorgement of soft tissues of eyes, swelling and cyanosis of lips, tongue, and gums, giant urticaria, severe itching, headache, and respiratory distress.	Within a few minutes.
	5. Elasmobranch toxin	Shark's liver (Prionace glauca, Mustelus canis, Squatina dumeril, and Somniosus microcephalus)	Generalized malaise, joint aches, nausea, vomiting, diarrhea, extreme fatigue, severe ataxia, violent pruritis, desquamation spasmodic contractions of eyelids, respiratory distress, cold sweats, delirium, coma, and death in many cases.	Unknown.
	6. Fresh-water fish poisoning	Roe or gonads of minnows of family Cyrinidae European barbel, Barbus barbus.	Headache, fever, dizziness, vomiting, colic and diarrhea, anuria, pallor, and prostration.	Within a few minutes to 6 hours.
Asari and oyster poisoning	Unknown	Asari and Oyster	Anorexia, abdominal pain, nausea, vomiting, constipation, and headache.	24 hours to 7 days.
Akee poisoning	Seeds and arils of unripe akee	Akee nut	Violent vomiting	2-3 hours.
Poison honey	Rhododendron (Andromeda) eaten by bees	Honey	Nausea, vomiting, diarrhea, dizziness, headache, temporary blindness, fainting, fever, complete unconsciousness.	Unknown
Tung-nut poisoning	Tung seeds	Tung-nut tree (Aleurites fordu)	Nausea, vomiting, diarrhea, abdominal cramps.	30 minutes

Botulism. This disease is caused by Clostridium botulinum which multiplies under anaerobic conditions producing a most deadly toxin in the food. Home-canned vegetables are the most usually involved food in the United States because of improper processing. In Europe, preserved meat is the most frequently involved food. The types of foods in the United States which have most frequently been involved in causing botulism are, in order of frequency: string beans, corn, spinach or chard, beets, asparagus, olives, beans, chili peppers, peas, beet greens, tuna fish, figs, salmon, ham, cheese, apricots, tomatoes, clams, mushrooms, okra, pears, sausage, sardines, green tomatoes, beef, blood sausage, chicken, pork, milk, other vegetables, meats and fish. In all these outbreaks, the food was canned, and only one out of every 9 outbreaks was caused by commercially packed foods. The rest were home-canned.

The natural habitat of Clostridium botulinum is the soil. It is a spore-forming, rod-shaped obligatory anaerobe of which 6 types have been isolated. The toxins of types A, B, and E have produced disease in man, but principally types A and B. Toxins of type C produce limberneck in fowl, and those of D produce botulism in cattle. These bacteria will scarcely grow in media whose pH is 5.5 or lower. To be sure, the medium should have a pH of 4.6 or lower to prevent botulism. The spores are resistant to heat, but they will be completely destroyed at:

100°C. for 360 minutes	115°C. for 12 minutes
105°C. " 120 "	120°C. " 4 "
110°C. " 36 "	

The toxins, in contrast to the spores, are susceptible to heat. Ten minutes at 100°C., or 30 minutes at 80°C. should destroy the toxins of types A, B and C. It is evident that the toxins are not destroyed when the foods are simply warmed. Therefore, boiling and thoroughly mixing should be the routine practice for home-canned foods. The subjection of the spores in a boiler for 6 minutes under 15 pounds pressure will destroy them. Growth of the organism and production of toxin will occur in concentrations of brine up to 8%. Preserving foods in at least 10% brine solution will make home-canned foods reasonably safe. Brine concentrations above 8% greatly decrease the heat resistance of spores, while heat resistance is enhanced by solutions of 0.5 to 1.0%. Heat resistance of spores increases with the concentration of sucrose. In satisfactory media, growth of organisms and toxin production occur within a few days at 20°C. This will not occur at less than 10°C. Toxin production may occur in frozen foods which are allowed to thaw and then are stored at 10°C. or higher. Cured canned meats containing 3.5% NaCl will inhibit growth and toxin formation.

TABLE 7 - FOOD-BORNE INTOXICATION OF BACTERIAL ORIGIN

Disease	Specific Agent	Foods Usually Involved	Signs and Symptoms	Incubation Period
Botulism	Toxin of Clostridium botulinum	Improperly processed canned food. Contaminated canned foods with pH over 3.5	Dizziness, lassitude, difficulty in swallowing, double vision (diplopia), difficulty in speech (aphonia), difficulty in respiration followed by death from paralysis of muscles of respiration.	2 hrs. to 8 days. Average: 12 to 48 hrs.
Staphylococcal Food poisoning	Toxin of Staphylococci, (boiling destroys germ but not toxin)	Improperly prepared custards, cream filled pastries, dairy products, bread pudding, potato and other salads, Hollandaise sauce, warmed over foods, meat, poultry, and many other protein foods.	Nausea, vomiting, diarrhea, acute prostration, and cramps.	1 to 11 hours. Average: 2-6 hours
C. welchii poisoning	Clostridium welchii (Type A)	Meat which has been boiled, steamed, braised, stewed, or insufficiently roasted and allowed to cool slowly and served the next day, either cold or reheated. Contaminated milk has been implicated.	Acute abdominal pain and diarrhea; nausea and vomiting are rare; fever, shivering, and headache are seldom seen.	8 - 22 hours.

Type A toxin has been prepared in pure crystalline form and has a molecular weight of 900,000. It is one of the most toxic materials known. One mg. contains about 20 million mouse lethal doses. The lethal dose for man is not known but is probably less than 1 microgram.

Although the typical symptoms of botulism usually appear within 12-36 hours after eating the involved food, shorter and longer periods have been cited. It is well for the sanitarian to compare the tables which describe the symptoms and periods of onset after eating in order that he may be able to use such data in aiding him to track down the causes of outbreaks. The treatment of botulism is at best unsatisfactory. There are effective polyvalent antitoxins, but they are usually not available when needed. The mortality for botulism is high in the United States, though low in Europe.

Table 8 - Number of Outbreaks of Botulism in the United States Resulting from Canned Foods 1940 - 1941

Year	Number of Outbreaks	Year	Number of Outbreaks
1930	5	1937	14
1931	16	1938	13
1932	19	1939	16
1933	22	1940	11
1934	9	1941	12
1935	21		
1936	9		

Table 9 - Data Collected by K. F. Meyer Concerning Botulism in the United States and Canada, 1899 - 1941

	No. of Outbreaks		No. of Outbreaks
California	145	Texas	3
Washington	50	Canada	2
Colorado	24	S. Dakota	2
Oregon	21	Utah	2
New York	19	Wisconsin	2
Montana	10	Alabama	1
New Mexico	9	Arizona	1
Wyoming	8	Arkansas	1
Idaho	7	Connecticut	1
Nebraska	6	Florida	1
Tennessee	6	Iowa	1
Ohio	5	Kansas	1
Illinois	4	Maine	1
Massachusetts	4	Minnesota	1
Michigan	4	Missouri	1
North Dakota	4	Oklahoma	1
Indiana	3	Virginia	1
New Jersey	3	West Virginia	1
Pennsylvania	3		
		Total	359

Botulism is prevented by the following measures:

1. Care in home canning; observation of safe techniques.
2. Fresh, firm fruits and vegetables should be thoroughly washed, cleaned, and canned as soon as possible after having been picked and gathered.
3. Non-acid foods, such as vegetables, meats, poultry, or fish should be processed in a pressure cooker for a specific period of time with an accurate gage and thermometer.
4. Where canning is done by any other method, the food should be reboiled for 15 minutes (actual boiling time) before tasting or eating.
5. Canned food having disagreeable odor or showing gas pressure in its container should not be tasted under any circumstances. Such food should be treated by adding several spoonsful of lye to can, then kept at least for 24 hours under surveillance before burying.

Clostridium welchii Food Poisoning. Several outbreaks apparently due to this organism have occurred in which milk, creamed chicken croquettes from precooked chicken, and insufficiently heated meats have been incriminated. The most prominent symptoms have been abdominal cramps and distention, and diarrhea; maybe nausea. Vomiting and fever have been rare. Incubation is about 8 to 22 hours. It is considered that Cl. welchii (Cl. perfringens) may at times produce an enterotoxin capable of producing the above symptoms. This organism is present in soil, water, milk, dust, sewage, and the intestinal canal of man and animals.

TABLE 10 FOOD-BORNE INFECTIONS OF BACTERIAL ORIGIN

Disease	Specific Agent	Foods Usually Involved	Signs and Symptoms	Incubation Period
Salmonellosis	Large group of Salmonella organisms	Meat, meat products, poultry, meat and poultry salads, egg custards, and other protein foods.	Abdominal pain, diarrhea chills, fever, vomiting, prostration.	5 to 72 hrs. Average: 12 to 24 hours
Streptococcal Food infection	Enterococcus Group S. fecalis (Lancefield group D), Pyogenic group S. pyogenes (Lancefield Group A)	Food products contaminated with human excreta. Foods contaminated by respiratory discharges of case or carrier.	Nausea; sometimes vomiting, colicky pains, and diarrhea; usually milder than staphylococcal food poisoning.	2 to 18 hours
Typhois Fever	Salmonella typhosa	Shellfish, water, milk, dairy products, other foods accidentally contaminated with excreta from human case or carrier.	Insidious onset with malaise, headache, fever, abdominal distress, diarrhea. In children, onset may simulate early pneumonia.	3 to 38 days. Average: 7 to 14 days.
Bacillary Dysentery (Shigellosis)	Shigella group of organisms	Any contaminated food or water	Diarrhea, bloody stools, fever.	12 hrs. to 7 days Average: 2 to 3 days
Brucellosis (Undulant fever)	Brucella abortus, Brucella melitensis, Brucella suis.	Raw contaminated milk, dairy products made from raw contaminated milk.	Insidious onset, fever, chills, sweats, weakness, malaise, headache, muscle and joint pains, loss of weight.	3 to 21 days; may be several months in some cases.
Diphtheria	Corynebacterium diphtheriae	Milk contaminated from human sources.	Insidious onset; inflammation of throat and nose.	2 to 7 days; usually 3 to 5 days.
Hemolytic streptococcal infections (Scarlet fever or septic sore throat)	Certain strains of Beta hemolytic streptococci	Foods contaminated with nasal or oral discharges from case or carrier; milk from cows with udders infected with these organisms.	Fever, sore throat; rash occasionally.	1 to 7 days; usually about 3 days.
Paratyphoid fever	Salmonella paratyphi A, Salmonella paratyphi B	Same as typhoid fever.	Fever, malaise; may resemble mild typhoid	1 to 10 days; usually a few days
Tuberculosis (Not pulmonary)	Mycobacterium tuberculosis (human and bovine types)	Raw, contaminated milk or other contaminated dairy products.	Depends upon part of body affected.	Variable.
Tularemia	Pasteurella tularense	Meat of wild rabbits, squirrels and similar animals.	Sudden onset with headache, chills, body pains, vomiting, and fever; swollen lympth glands.	1 to 10 days; usually about 3 days.

Staphylococcus Food Poisoning. This type of food-borne bacterial poisoning, like botulism is produced by a toxin formed by the staphylococcus bacteria in the food before ingestion. It is probably the most common of all food-borne poisonings. Its symptoms are different from botulism (Table 7). The conditions necessary for an outbreak of this food poisoning are:

1. Contamination of food by toxin producing staphylococci.
2. The food must be suitable for growth of staphylococci.
3. The keeping of this food for a sufficient period of time (about 5 hours) at a temperature compatible with rapid growth and enough toxin production.

Food poisoning staphylococci have been found to grow in low-acid foods: peas, corn, salmon, and shrimp. Less abundant growth occurs in canned string beans, spinach, and asparagus. Staphylococci grow luxuriantly in canned roast beef, corned beef, potted meat, chicken a la king, creamed tuna, ham a la king, creamed salmon, turkey and noodles, and cooked shrimp. Outbreaks have been traced to ice cream, and frozen fish.

The types of foods which have been incriminated in such outbreaks are cream, cake, cheese, chicken gravy, milk, custard pie, cream-filled eclairs and tarts, custard-filled doughnuts, chocolate eclairs, dried beef, tongue sandwiches, hams and tongues, hollandaise sauce, fish sausage and liver sausage. Bacteriostatic agents such as thioglycollic acid, DL-serine, L-cysteine, and glycine should not be depended upon to control staphylococcic growth in contaminated cream pastry filling. Outbreaks traced to pies and pastries are most numerous, and those due to pork and pork products hold second place. Rapidly cured hams have given rise to many outbreaks. These must be kept under refrigeration at all times. Toxin producing staphylococci will not grow in meat when dehydrated to a moisture content lower than 30%.

In order to have a product with a minimum bacterial content after cooking,it is recommended that custard be cooked at a temperature of at least 190°F. for ten minutes in steam jacket vessels with facilities for agitation to prevent scorching, and then cooled in the same vessel.

The eggs used should be whole shell eggs (with breaking just before preparation), pasteurized can eggs, or egg powder used in the same manner as the reconstituted milk powders.

In routine preparation observed by Plotkin*, the custard product yielded a count of 5 million colonies per gram after storage for 6 hours at 37°F., contrasted with only 400 colonies per gram under similar conditions after instruction on observance of the following rules:

1. Wash hands thoroughly with soap and hot water before starting preparation of the product. Never neglect to wash hands carefully after using the toilet. Dry hands with individual towels.

2. Employees with open cuts, burns, sores, stomach upset or who are otherwise ill should not prepare this product.

3. Utensils such as sauce pans, crocks, wire beaters, ladles, etc., should be washed thoroughly with soap or detergent and hot water, and rinsed and placed in boiling water for two minutes. Receptacles should be handled so that fingers do not come in contact with inside portion.

4. The product should not be transferred to another receptacle for cooling, but should be in the same container in which it was cooked.

5. Care must be exercised to prevent contamination in transferring the cooled custard filling to the napoleon layers, boston cream pies, etc. If a filling machine be used, it must be disinfected before use.

6. Custard filling and custard-filled pastries should be chilled rapidly -- in one hour or less to 45°F. or less -- and kept at that temperature during storage, transportation, and display, and until consumed.

7. The retail baker, particularly, should supply a notice to the consumer that custard-filled baked goods must be kept under constant refrigeration in the home until consumed.

The staphylococcic germs are found everywhere in nature. Not all staphylococci produce toxins and there is no satisfactory manner of determining which type will or will not produce

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* The Control of the Sanitary Quality of Custard, Samuel Plotkin, Sanitarian Journ. Environmental Health, Vol. 25, No. 1, pp. 34-38, 1962.

food poisoning. It appears that the number toxin producing strains of staphylococci are small in comparison to the non-toxin producers. Foods may be contaminated from sores, boils, carbuncles, post-nasal discharges, sinus infections, sore throats, and carriers. This germ will grow well in cured meat, in salted meat, and in chicken containing 5 to 10% salt. They are found to grow in concentrations of salt or sugar which are inhibitory to many bacteria.

Heat will destroy the staphylococci and good refrigeration will prevent them from growing and producing toxin. Toxins will not be produced at temperatures below 6.8°C. (44°F.). Freezing will not destroy staphylococci. It is recommended that a routine practice should be adopted for reheating custard fillings in eclairs, cream pies, and similar food at temperatures ranging from 190.6°C. (375°F.) to 216°C. (420°F.) for 30 minutes. This process has been shown not to impair the appearance or palatability of the pastries. If, however, a tendency toward excessive browning does occur, egg white should be substituted for milk in the manufacture of shells. The staphylococcic toxin is very heat resistant but gradually loses its potency with prolonged boiling or autoclaving. The toxin can withstand boiling for an hour, and autoclaving for 20 minutes at 120°C. under 15 pounds pressure.

Growth of staphylococci depends on competition with other organisms. It is possible for staphylococci to produce toxin in vivo in patients who have been treated with antibiotics which have disturbed the intestinal flora and reduced competition for staphylococci in the intestinal tract.

There is no specific drug or serum that is of value for treatment of this disease. The symptoms of this disease appear in about 3 hours and occasionally from 1 to 6 hours after ingestion of the poisoned food.

Food-Borne Salmonella Infection. This disease may be caused by eating food in which large numbers of paratyphoid organisms have grown. It is not caused by bacteria-produced toxins, but by the ingestion of large numbers of bacteria. The symptoms may be similar to those of staphylococcic food poisoning but the period of onset of symptoms after eating is longer, averaging around 12 to 24 hours. Typhoid fever may also be a food-borne infection.

It is necessary to demonstrate living paratyphoid organisms in specimens of food submitted for bacreriological examination in order to substantiate a diagnosis of paratyphoid infection of the food-borne type, and even better, also finding the organism in the stool.

Common foods that have been involved in food-borne salmonella outbreaks are: bread pudding, milk, cheese, mutton, puddings made with infected eggs.

Cattle, swine, etc. with salmonella infection that are slaughtered may cause this disease if the meat be eaten in an uncooked condition. The meat or other products may become contaminated by droppings of infected rats or mice. The places where meat is stored may be contaminated with salmonella, or the equipment, knives, and floors of slaughter houses may be contaminated. Eggs may be infected while growing in the fowl and may later contaminate the food into which such eggs are put without adequate cooking. Milk and cheese from diseased cows may produce disease in humans if subsequently not pasteurized. Houseflies may spread this disease. Flies may spread the germ to other flies. Contaminated fly eggs may cause the salmonella to persist in maggots, pupae, and adult flies. The germs may live in flies during their entire life. The two principle species of paratyphoid bacteria in U.S. which cause food-borne infections are Salmonella typhimurium and Salmonella paratyphi B. A number of other salmonella have been implicated. Paratyphoid bacteria produce two types of symptoms in man, the type manifesting a fever like typhoid fever, called paratyphoid fever, and that type which manifests acute intestinal upsets. In the laboratory the salmonella organisms are classified according to their biochemical reactions such as fermenting various sugars, and according to their serological or antigenic (ability to produce antibodies) reactions. If classified according to their biochemical reactions, only a relatively few types are separated, but if classified according to their immunological reactions, several hundred types of paratyphoid organisms have already been distinguished.

Although the sanitarian is not expected to be an expert on salmonella organisms, Table 11 is presented to indicate to him those paratyphoid salmonella which have been isolated up to

recently, those which have been found to produce diseases in man, those which have been found in the stools of apparently normal persons, and those which have been found only in animals. The table also shows from which animals other than man the particular organisms have been isolated. Thus, if a report from the laboratory be returned indicating the particular organism involved in a food-borne disease outbreak,the sanitarian may have an instrument in this table that may give him direction when doing an epidemiological investigation as to the source of the organism. Many of the organisms in the list have not yet been found in the United States, but since communications have eliminated space barriers in the spread of diseases, these organisms may become important to us in the future as causes of food-borne infection.

The paratyphoid salmonella are divided into 6 large groups, A, B, C, D, E, and F. There is a wide difference between the view point as to whether the salmonella should be classified according to their biochemical or serological reactions. The biochemical method of classification designates 5 types of salmonella as important in human disease, namely; Salmonella paratyphi A, Salmonella paratyphi B, Salmonella paratyphi C, Salmonella typhi, and Salmonella sendai, and 6 important types in veterinary medicine, namely; Salmonella typhimurium, Salmonella abortusequi, Salmonella choleraesius, Salmonella enteritidis, and Salmonella gallinarium-pullorum. The serological method distinguishes many sub-species within these several types.

In order to further to aid the sanitarian in his reading, the following table of synonyms are given:

Species	Synonyms
Salm. typhi	B. typhi, B. typhosus, Bact, typhosum, E. typhis, E. typhosa.
Salm. paratyphi A.	B. paratyphosus A, Bact. paratyphosum A.
Salm. paratyphi B.	B. paratyphosus B. Bact. paratyphosum B, S. schottmeulleri.
Salm. paratyphi C.	S. hirschfeldii.
Salm. typhi-murium	Bact. aertrycke, Bact. typhi-murium.
Salm. cholerae-suis	Bact. suipestifer, Bact. cholera-suis.
Salm. enteritidis	Gaertner's bacillus, Bact. enteriditis.

There is no specific serum for this disease. Sanitation and adequate food storage are the best preventive measures.

Streptococci Food-borne Infection. From present evidence, this disease is caused by eating food in which large numbers of alpha-type Streptococcic bacteria have grown. Like salmonella food-borne infection, this disease is not caused by bacteria- produced toxins, but by ingestion of large numbers of bacteria. Some foods which have been incriminated in this type of food-borne infection are: canned Vienna sausage, beef croquettes, cocoanut-cream pit, and turkey dressing. The alpha-type streptococci are constantly found in the human mouth and throat and in cattle feces. These organisms are readily killed by pasteurization. The onset of illness from the time of eating the contaminated food is longer than for staphylococcic food poisoning, varying between 5 and 18 hours. There is no specific serum treatment for this disease.

Table 11 Salmonella That Have Been Identified In Man and Animals, Where Isolated, Group to Which Each Type Belongs. (FG stands for Further Groups)

Type	Group	Where Isolated*	Type	Group	Where Isolated*
S. abadina	FG	1	S. aderike	FG	1
S. aberdeen ##	F	1,2	S. aequatoria	C	1
S. abony	B	1,3,9	S. agona	B	3
S. abortus-bovis	B	1,3	S. alachua	FG	4
S. abortus-equi #	B	1,2,8	S. albany #	C	1
S. abortus-ovis	B	5	S. allandale	FG	1
S. adelaide	FG	1,2,6,9	S. altendorf	B	1

Table 11 - Continued

Type	Group	Where Isolated*
S. amager	E	1,6
S. amersfoort	C	1,2
S. amherstiana	C	2
S. anatum ##	E	1,2,3,4, 5,6,7,8, 9,13,b,c
S. arechavaleta #	B	1,2
S. ashanti	FG	6
S. atlanta	G	1
S. azteca #	B	1
S. ball	B	1
S. banalia	C	1
S. bareilly ##	C	1,2,4,7, 10,13,b,c
S. berkeley	FG	2
S. berta ##	D	1,2,4, 13,a
S. binza	E	1
S. birkenhead	C	1,9
S. bispebjerg	B	1
S. blegdam	D	1,6
S. blockley ##	C	1,2,13,a
S. blukwa	FG	1
S. bodjonegoro	FG	3
S. bolton	E	1
S. bonair	FG	3
S. bonariensis ##	C	1,4,9
S. bonn	C	1
S. borbeck	G	1
S. bovis-morbificans ##	C	1,2,3,5, 6,8
S. braenderup ##	C	1,2,7,a
S. brancaster ##	B	1,2,3,11
S. brandenburg ##	B	1,2
S. bredeney ##	B	1,2,4,5,7 12,13,c
S. bronx	C	1
S. budapest	B	1,2
S. bukavu	FG	1
S. businga #	C	1
S. butantan	E	1
S. cairina	E	2
S. california #	B	1,2,4,7, 10,13
S. cambridge	E	1,2,6,7
S. canada	B	1
S. canastel	D	1,9
S. canoga	E	2
S. cardiff	C	1
S. carrau	H	1,4
S. cerro #	FG	1,2,4,7, b,c
S. champaign	FG	2
S. chester ##	B	1,2,4,6,7 9,b
S. chicago	FG	1,2
S. chingola	F	1
S. chittagong	E	1
S. cholera-suis ##	C	1,2,3,4,6,7
S. claibornei	D	1
S. clerkenwell	E	1
S. colombo	FG	
S. colorado	C	1
S. concord	C	1,2,7
S. coquilhatville #	E	1
S. corvallis	C	2,9
S. cubana #	F	1,2,7,13, a,c
S. dahlem	FG	1
S. dar-es-salaam	D	1
S. daytona	C	1
S. decatur	C	1
S. degania #	FG	1
S. denver	C	1
S. derby ##	B	1,2,3,4,6, 7,10,13,c
S. donna	FG	7
S. dublin ##	D	1,2,3,4,5, 6,7,8,10
S. duesseldorf	C	1,2
S. durban	D	1
S. duval	FG	7
S. eastbourne	D	1,2
S. edinburg #	C	1
S. elizabethville	E	1,2
S. emek	C	1,2
S. enteriditis ##	D	1,2,3,4,5, 6,7,10,12, 13
S. eschweiler	C	1
S. essen	B	1,2,5
S. fayed #	C	1
S. farcha	FG	5
S. florida	H	1,9,13,a,c
S. frintrop	D	1
S. gallinarum	D	1,2,13, a,b
S. garoli	C	1
S. gaminara #	I	1,2,7
S. gatuni	C	1
S. georgia #	C	1,2
S. germiston #	C	1
S. give ##	E	1,2,3,4,7, 13,b,c
S. glasgow	I	1
S. glostrup #	C	1,7
S. goerlitz #	E	1
S. goeteborg #	D	1
S. goettingen	D	2
S. gombe	C	1
S. greiz #	FG	1

Table 11 - Continued

Type	Group	Where Isolated*	Type	Group	Where Isolated*
S. grumpensis	G	1,6,13	S. limete	B	1
S. haifa	B	1	S. lindi	FG	1
S. hannover	I	1	S. litchfield #	C	1,2,a,c
S. harrisonburg	E	2	S. livingstone	C	1
S. hartford ##	C	1	S. locarno #	FG	1
S. havana	G	1	S. loma-linda#	D	1
S. heidelberg ##	B	1,2,4,c	S. lomita #	C	1,2,4,7
S. hessarek	B	2	S. london #	E	1,2,4
S. heves	H	1	S. luciana	F	1
S. hidalgo	C	2	S. macallen	E	7
S. hillbrow #	FG	1	S. madelia	H	1,2,a
S. homosassa	H	7	S. magwa	FG	
S. horsham	H	2	S. makiso	C	1
S. huvudsta #	E	1	S. makumira	B	2
S. hvittingfoss	I	1,2,3	S. manchester	C	1,9
S. ibadan	G	1	S. manhattan #	C	1,2,4,7,9, 13,b,c
S. illinois #	E	1,2,4,7,13			
S. infantis ##	C	1,2,4,13, b,c	S. manica	D	3
			S. marseille	F	1
S. inverness	FG	1	S. matadi	FG	1
S. irenea #	FG	1	S. matopeni	FG	1
S. irumu #	C	1,2,9	S. mbandaka	C	1
S. israel	D	1,7	S. meleagridis ##	E	1,2,4,5,7, 9,13,b,c
S. ituri	B	2			
S. jamaica #	D	1	S. memphis	FG	1
S. java ##	B	1,13,a,c	S. menston #	C	1
S. javiana ##	D	1,2,7,13, a,b,	S. mgulani	FG	1
			S. miami #	D	1,a
S. jerusalem	C	1	S. mikawasima	C	6
S. johannesburg #	FG	1	S. millesi	FG	3
S. kaapstad	B	1	S. milwaukee #	FG	1
S. kalamu #	B	1	S. minnesota ##	FG	1,2,3,7, 13,b,c
S. kaolack #	FG	1			
S. kaposvar	B	1	S. mishmar-haemek	G	1
S. kasenyi	FG	2	S. mission	C	7
S. kentucky #	C	1,2,3,4,7, 13,c	S. mississippi #	G	1
			S. monschaui	FG	1
S. kibusi	FG	1,9	S. montevideo ##	C	1,2,4,6,7, 9,13,b,c
S. kimuenza	B	1			
S. kingston	B	2	S. morehead	FG	1
S. kinshasa	E	1	S. morotai	FG	1
S. kirkee ##	FG	1	S. moscow	D	1,3,8
S. kisangani	B	1	S. muenchen ##	C	1,2,3,4,6, 7,9,13,b,c
S. kivu	C	1			
S. koeln	B	1,9	S. muenster #	E	1,2,8
S. kottbus #	C	1,2,8,9	S. nagoya	C	1
S. krefeld	E	1	S. napoli	D	1
S. larochelle #	C	1	S. narashino	C	1
S. lawndale #	D	1	S. nchanga ##	E	1
S. leeuwarden	F	1	S. ndolo	D	1
S. leoben ##	FG	1	S. ngozi	FG	7
S. leopoldville	C	1,9	S. neasden	D	1
S. lexington	E	1,2,4	S. ness-ziona	C	1,2
S. lille	C	2	S. neukoelln	C	1

Table 11 - Continued

Type	Group	Where Isolated*
S. new brunswick	E	1,2,3,4,5,7
S. newington ##	E	1,2,3,4,6,7,8,10,13,b,c
S. newlands	E	1
S. newport ##	C	1,2,3,4,6,7,8,9,10,13,b,c
S. niamey	FG	1
S. niarembe	FG	1
S. niloese	E	1,2,10
S. norwich	C	1,2,4
S. nottingham	I	1
S. nyborg	E	1
S. odozi	FG	1
S. onarimon	D	1,4
S. onderstepoort	H	2,4,5,9
S. oranienburg ##	C	1,2,3,4,7,13,b,c
S. orientalis	I	1,3
S. orion	E	1
S. os	D	1
S. oslo	C	1,2
S. oxford	E	6
S. panama ##	D	1,2,3,4,9,13,c
S. papuana	C	1
S. paratyphi A ##	A	1,2,3,4,6,7,13
S. paratyphi B ##	B	1,2,3,4,5,6,7,8,12,13,c
S. paratyphi C ##	C	1,4,6
S. pensacola	D	1,6
S. pharr	F	7
S. phoenix #	FG	1
S. pomona	FG	2
S. poona #	G	1,2,4,5,6,7,13,b
S. potsdam	C	1,5,9
S. pretoria	F	4
S. pullorum ##	D	1,2,3,4,7,b,c
S. quiniela	C	7
S. reading ##	B	1,2,4,6,13
S. richmond	C	1
S. rio grande	FG	7
S. rostock	D	3,4,7
S. rubislaw #	F	1,2,4,9,13,a
S. saint paul ##	B	1,2,4,8,13,c
S. salford	I	1
S. salinatis	B	6
S. san diego #	B	1,2,4,9,13,c
S. sanga	C	1
S. san-juan	C	2,7
S. schlessheim	B	3,4,8
S. schoeneberg	E	1
S. schwartzengrund #	B	1,2,6,b,c
S. selandia	E	1,3,4
S. sendai ##	D	1
S. senegal #	F	1,9
S. senftenberg #	E	1,2,4,13,a,b,c
S. seremban	D	1
S. shangani	E	1
S. shanghai	I	1,9
S. shikmonah #	FG	1
S. shoreditch	D	1
S. siegburg #	FG	1,2,b
S. simi	E	1,2
S. simsbury	E	1,2,a
S. singapore	C	1
S. solt	F	1
S. stanley ##	B	1,3,6
S. stanleyville	B	1,2,9
S. sterrenbos	C	1
S. stockholm	E	4
S. straengnaes	F	1
S. sundsvall	H	2,9
S. szentes	I	1
S. tafo	B	3
S. taksony #	E	1,2
S. tallahassee	C	1,a,c
S. tananarive	C	4
S. tchad	FG	3
S. techiman	FG	3
S. tel-aviv #	FG	1,2,3,7
S. tel-hashomer	F	1
S. tennessee ##	C	1,2,6,7,13,b,c
S. texas	B	1
S. thomasville	E	7
S. thompson ##	C	1,2,3,4,6,8,13,b
S. tilburg	E	4
S. tinda	B	2,13
S. tournai #	E	1
S. tunis ##	G	1
S. typhi ##	D	1,2,7,13,a
S. typhimurium ##	B	1,2,3,4,5,6,7,8,9,10,12,13,b,c
S. typhi suis	C	4
S. uganda #	E	1

Table 11 - Continued

Type	Group	Where Isolated*	Type	Group	Where Isolated*
S. uno #	C	1	S. weltevreden #	E	1
S. urbana	FG	1,2,4,13, a,b	S. weslaco	FG	7
			S. westhampton	E	7
S. uzaramo	H	1	S. wichita	G	1,2,4
S. vancouver	I	1	S. wien ##	B	1
S. vejle	E	1,2,3	S. wil #	C	1
S. veneziana	F	1	S. windhoek #	FG	1
S. virchow #	B	1,4	S. woodstock #	I	1
S. virginia	C	1	S. worcester #	G	1
S. volta	F	4	S. worthington #	G	1,2,3,4,6, 7,13,b,c
S. wa	I	3			
S. wagenia	B	1	S. yolo #	FG	1
S. wangata #	D	1	S. zanzibar	E	1,2
S. waycross	FG	1,9	S. zega	D	2

* Code indicating where the particular Salmonella has been isolated.

Man	= 1	Cattle	= 3	Reptile	= 9
Animals (Unspecified)	= a	Swine	= 4	Fox, mink	= 10
		Sheep, Goat	= 5	Shellfish	= 11
Eggs	= b	Rodents	= 6	Insect	= 12
Foods (Unspecified)	= c	Dog, Cat	= 7	Water and Sewage	= 13
		Horse	= 8		
Fowl	= 2				

\# signifies salmonella type isolated from human case.

\## signifies salmonella type isolated from epidemic among humans.

Those types isolated from man but not from case or epidemic signify that they were from human carriers.

Other Bacterial and Parasitic Food-borne Infections. Amebic and bacillary dysentery germs and a number of different types and varieties of bacteria and viruses may be food-borne and may cause specific dysentery diseases or non-specific diarrheas. Such bacterial diseases as tuberculosis, hemorrhagic jaundice, and undulant fever may also be food-borne. These diseases are more fully dealt with in the chapter on Communicable Diseases and in other chapters pertinent to the discussion of these diseases. Many other organisms have been incriminated in food-borne outbreaks, but with no conclusive evidence. Some of these organisms are: Escherichia coli, Proteus vulgaris, and the Cloacae-Aerogenes group.

There are many infections which may simulate food poisoning and give rise to diarrhea, abdominal cramping, nausea (with or without vomiting), and pyrexia. These infections must be ruled out, however, in dealing with food poisoning. There is one outstanding difference between food poisoning and other infections. Food poisoning, in its inception, is generally of an explosive nature, whereas epidemics of infectious disease may break out over a period of several days.

Bacillary Dysentery. Man is a natural host for bacillary dysentery. Shigella organisms which are pathogenic for man have not been reported in domestic animals which furnish meat for food. In areas in which typhoid fever and cholera are controlled, bacillary dysentery remains endemic. Bacillary dysentery may be spread by food contaminated with feces of carriers or cases. In any outbreak, differentiation from food poisoning is more by the fact that the cases appear over a period of days rather than within a short space of time, and the bacilli can be recovered from stools by culture.

Infectious Hepatitis. This viral disease may be food-borne. It has an incubation period of 10 to 40 days, or an average of 25 days. The disease is characterized by the following symptoms: anorexia, general malaise, fatigability, headache, nausea, chills and fever, vomiting, and upper-right abdominal tenderness. Jaundice may or may not be present. It has been demonstrated that the fecal carrier state may last 5 to 15 months.

Amebic dysentery. This disease may be food-borne. It is differentiated from food poisoning by being of an insidious and chronic nature. The incubation period from the time of ingestion of the amebae to the onset of symptoms may vary from less than 1 week to 4 months.

Trichinosis. The early stage of trichinosis has been confused with food poisoning. When encysted larvae are eaten, the cysts are digested in the patient's stomach, whereupon the larvae are liberated in the duodenum. They invade the duodenal and jejunal mucosa and give rise to symptoms such as nausea, vomiting, diarrhea, dysentery, colic, and profuse sweating. It is in this stage of the infection, about 48 hours after ingestion of the larvae, that the disease must be differentiated from food poisoning. When the larvae migrate into the tissues, patients may develop a severe myositis, spastic paralysis of the muscles, and edema of the face and hands. A marked eosinophilia is suggestive of trichinosis. During the intestinal phases, adult worms are sometimes recovered from the feces.

Epidemics of Acute Digestive Upsets of Viral or of Unknown Etiology. These include gastrointestinal illnesses of acute nonbacterial gastroenteritis. Epidemics of acute digestive upsets which are not apparently associated with food or water have been reported in widely scattered localities. The onset is mostly gradual, beginning with nausea, vomiting, and diarrhea. Fever may be present. The patients become ill over a period of hours. In some individuals, the illness is associated with colds, but in many there is no history of any upper respiratory infection. Some of the ambulatory patients remain ill for only a few hours, whereas others stay ill for 2 to 3 days. Although outbreaks of nonamebic, nonbacterial enteritis do not appear to be food-borne, food cannot be excluded as a vehicle of infection until more is known of the causative agents and their ability to survive in nature outside the host. Since this type of infection simulates the symptoms of food poisoning, it is important that the two be differentiated. A striking difference is that non-bacterial epidemic diarrhea has not been related to food or water and that an epidemic in a community may cover a period of many weeks. Certainly, it is of utmost importance to exclude these illnesses from the category of food-poisoning outbreaks.

TABLE 12. FOOD-BORNE INFECTIONS OF NONBACTERIAL PARASITIC ORIGIN

Disease	Specific Agent	Foods Usually Involved	Signs and Symptoms	Incubation Period
Amebic dysentery (Amebiasis)	Endamoeba histolyica	Water contaminated with sewerage; moist food contaminated with human feces.	Diarrhea varying in severity, causes liver damage; fatalities are not uncommon.	Several days to 4 weeks.
Beef tapeworm (Taeniasis saginata)	Taenia saginata	Raw or insufficiently cooked beef containing live larvae.	Abdominal pain, hungry feeling, vague discomfort	Several weeks.
Fish tapeworm (Diphyllobothriasis)	Diphyllobothrium latum	Raw or insufficiently cooked beef containing live larvae.	Usually none; some present a variety of symptoms; anemia in heavy infection.	3 to 6 weeks.
Pork tapeworm (Taeniasis solium)	Taenia solium	Raw or insufficiently cooked pork containing live larvae.	Varies from a mild, chronic digestive disorder to severe malaise with encephalitis which may be fatal.	Several weeks.
Trichinosis	Trichinella spiralis	Raw or insufficiently cooked pork and pork products, whale, seal, bear or walrus meat containing live larvae.	Nausea, vomiting, diarrhea, muscular pains, fever, labored breathing, swelling of eyelids; occasionally fatal	2 to 28 days. Usually 9 days but may vary. In heavy infections 24 hours.

Frozen Precooked Foods*

One of the most interesting developments in the frozen food industry - and perhaps an expected outgrowth, considering the eager acceptance of such convenience foods - has been the emergence of frozen precooked foods requiring the consumer to do little more than heat and serve complete meals from packages stored in a freezer. The production of frozen precooked foods has substituted the manufacturing plant for the kitchen of the consumer and in so doing has shifted the quality control of the food from the housewife to the manufacturer. The housewife must accept on faith that such products are prepared from clean, sound, and wholesome raw materials and that the food is mixed, compounded, prepared and packaged under sanitary conditions at least comparable to those prevailing in her own kitchen. It is the responsibility of Public Health Agencies to insure that this expectation of the consumer be fulfilled.

Generally, the inspections of plants producing frozen precooked foods have revealed that sanitary conditions and operating practices are considerably below the level desired for a non-sterile food product which is not given a final heat process, which may be subjected to varying degrees of mishandling in commerce, and which may be consumed without sufficient heating or cooking to destroy micro-organisms.

While there is a great variation in the physical size, design, and availability of technological skills in establishments producing such foods, it appears that they have certain sanitation problems in common. These sanitation problems relate to two general areas: (1) those which affect the type and quantity of contamination, and (2) temperature-time abuses which exert a strong influence upon the number of micro-organisms found in the finished products.

Personnel practices: Among the principal sources of bacterial contamination in foods are: (1) the food handlers, and (2) the contact surfaces of equipment used in the preparation of the food. Some fundamental concepts in good food handling practice are rather generally ignored throughout the frozen precooked food industry. Adequate handwashing and handsanitization before handling food products are basic to food sanitation, but in a very small percent of plants are good handwashing practices usually found. Sanitization of hands is very seldom found. In some plants, sanitizing dips are available to the employees but usually not used. Strict supervision of employee work habits is the missing link between sanitizing facilities and employee practices. Therefore, the supervisors' interest, alertness, and diligence to sanitary practice is the key to the quality of frozen precooked food.

Equipment: In most instances, cleanup procedures at the end of a processing operation is satisfactory to make equipment and utensils physically clean, although, it is not unusual to find dried encrustations of food on utensils remaining from previous operations in some plants. But too often the equipment and utensils are left unprotected overnight and then used the next day without further washing or rinsing. Sanitizing the food contact surfaces of equipment is not a frequent practice. Periodic cleanup of equipment at intervals during the operating day is rarely done. Plants' employees too frequently use cloths and rags for a variety of purposes, such as to dry hands, to wipe wet table surfaces, and to wipe small utensils.

Time-Temperature Relationship: Micro-organisms flourish in a moist, nutritious environment under warm temperature conditions and will increase in numbers in direct relations to the time spent in these favorable conditions. Most components of frozen precooked foods provide the required nutrients for bacterial growth. Insanitary handling introduces a number and variety of organisms. Prolonged holding of food at warm temperatures is all that is required to permit the growth of micro-organisms. While there may be a general recognition in industry of these fundamental concepts, it is obvious that their true significance is not fully appreciated. The control of temperature and time in food operations is essential to limit the growth of bacteria in the food product. The improper control of these two factors is the major reason for the high bacterial content of some finished frozen precooked foods.

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*A Bacteriological Survey of the Frozen Precooked Food Industry. U.S. Food and Drug Administration, 1959.

The effect of this lack of control of time and temperature can be appreciated from the following example: If the aerobic plate count of a refrigerated mix to be packaged and frozen without further cooking be 600 bacteria per gram, the count will be around 1,500 per gram if kept standing at room temperature until midmorning. By early afternoon the count may reach 320,000 and 660,000 per gram. The counts of the finished frozen product after packaging, with the packages placed in master cartons for blast freezing, may range from 5 million to 10 million per gram. Not only does this example illustrate the danger of holding even a product of good bacteriological quality for several hours at room temperature, but also demonstrates a general fault in this industry - that of blast freezing a number of packages in a master carton. There seems to be little appreciation of the time required for heat transfer to take place within a package placed in a blast freezer. When several individual packages are placed tightly together in the insulating container of a master carton, it will be hours before the temperature in the package will drop to a point where bacterial growth will be inhibited.

It should be recognized that refrigeration above freezing temperature is a temporary expedient at best, because certain bacteria can and do grow at refrigeration temperatures. In time they attain large numbers and eventually spoil the product. High bacterial counts are found in many cooked ingredients which are stored for prolonged periods.

Analytical Results: With the number and diversity of frozen precooked foods to be examined, it is extremely difficult to gain an overall picture by considering each food product individually. In an attempt to consolidate the numerous examinations and products, it appears logical and convenient to establish four major groups of these foods. These groups are defined in relation to the amount of cooking which the product may be expected to receive in the home and of cooking received by the product at the time of manufacture. The categories are as follows:

Table 13

Group	Product	Cooking Required
I	Bakery products, cream pies, cakes	Product does not require warming prior to serving.
II	Variety of products - spaghetti, macaroni and cheese, potato products, blintzes, knishes, and some other meat and seafoods.	Product requires warming prior to serving. Cooked early in production process, then combined with other items before packaging or freezing.
III	Crab cakes, fish cakes, Chinese foods, and specialty products.	Product requires warming prior to serving. Cooked late in production just prior to packaging or freezing.
IV	Poultry, tuna, beef, and lobster pies; pizza; and raw breaded shrimps.	Product requires cooking prior to serving.

Generally, it appears that the aerobic plate count and coliform content of frozen precooked foods vary with production processes and serve as rough guides to plant sanitation. Plate counts and coliform content are related to equipment cleanliness and to time and temperature of holding periods. E. coli findings are related principally to personnel contamination, but in products containing raw natural cheeses or uncooked eggs, coliforms, including E. coli, occur frequently. The finding of coagulase positive staphylococci is usually related to employee contamination of the product during an operation requiring a great deal of handling. The deboning of poultry and dicing of meat are examples of operations often leading to staphylococcus contamination. Products containing a natural cheese may show a low incidence of coagulase positive staphylococci.

Recommendations: It is apparent that considerable improvement is needed in facilities, processing techniques, personnel supervision and control in many plants, and in the scheduling of operations to avoid time and temperature abuses encountered under current commercial practice which are reflected in the microbial content of the finished products. There is no doubt that lower levels of microbial content can be readily attained by industry, since it has been found that products packed during inspection show substantially lower contamination than the same products packed prior to inspection.

Data are not yet available and sufficient to permit the establishment of reasonable bacterial limits for frozen precooked foods. However, the data which are available clearly indicate that, in assessing the microbiological content of these products, not only numbers of aerobic organisms but also coliforms (fecal E. coli, and coagulase positive staphylococci) must be considered. While coliform bacteria and E. coli tend to parallel the aerobic plate count, there are many instances where they indicate insanitary conditions or practices not reflected by the plate count. The incidence and levels of coagulase positive staphylococci reflect human handling of the products subsequent to cooking, and may be hazardous when associated with time-temperature abuse. Therefore their determination is both informative and useful.

Analytical data may be used to corroborate the inspectional report. If plant inspection indicates poor sanitation and/or abuses in temperature-time, and if examination of samples shows an excess of bacteria not found in good commercial practice, then a regulatory agency is justified in considering a product illegal since it was produced under insanitary conditions.

The division of products into different groups on the basis of treatment received during production and use appears grossly valid. It seems rather obvious that the heat treatment (or lack of it) received during processing influences substantially the microbial content of the finished products. Those products cooked or heated in essentially finished form prior to packaging and freezing (Group III) are of particular interest and comprise nearly half of the finished samples. These products may show substantial contamination because of inadequate or superficial cooking, recontamination, and delays in freezing. However, heating destroys such a large proportion of the micro-organisms originally present that bacteriological examination of the finished products will not reveal its true sanitary history. Evaluation of these products will have to be based primarily upon factory observations of sanitary conditions, tests of ingredients and finished products prior to final cooking.

The variability innate to the enumeration of micro-organisms and hour-to-hour changes during production of food in a plant demand the examination of many samples to give a fair picture of the bacterial content of the product. The larger the sample size the more accurate the results will be in depicting the true bacterial content of the lot. Statistical analysis of the aerobic plate count examination of a sample of 10 units appears to represent the best sample size which combines practicality with a reasonable degree of valid information.

Food Control Legislation

Development of Food Control Legislation. Adulteration and misbranding are fraudulant practices stimulated almost always by the motive to make more profit. Prior to the passage of the Federal Pure Food and Drug Act in 1906, a large percentage of the food sold in the United States was found to be adulterated in one way or another. The history of the struggle for the passage

of national food and drug legislation in the United States when reviewed in detail, is one of the most distasteful chapters in modern public health development in our country.*

Effective food control has developed principally as a result of three factors: The gradual change of the manufacture of food from home to factory, the development of bacteriology and chemistry, and the educational work carried on by the official and voluntary health agencies. As a result of the operation of these three factors during the first decade of the existence of the American Public Health Association, the States began to consider and, in a few instances, to enact, legislation for control of traffic in food. New York in 1881 enacted the first state food control laws. In the same year Michigan, New Jersey and Illinois followed New York's example. In 1883 Maine, Nebraska and Ohio came in; in 1885, Massachusetts and Pennsylvania; in 1887, Virginia; in 1888, Iowa and Vermont; in 1889, Connecticut, Kansas, and Wisconsin. From 1890 to 1895 laws of general or specific nature were passed in Maryland, New Hampshire, New York, Colorado, California, Georgia, Indiana, North Carolina, North Dakota and Washington. During the decade following 1895 the state legislatures were active in amending old and in passing new food laws. The purity and wholesomeness of foods are now regulated by statutes in all States. In 1950, regulatory control of production, processing, packaging, and storing of milk was the function of 33 state health departments; of shellfish, 29 state health departments; and of other foods, 30 departments. Some functions in food sanitation, regulatory or otherwise was the function of all state health departments. In 23 states, the state health departments function in practically all phases of food control.

The economic features of food adulteration were early recognized and published in the "Transactions of the Medical Society of the State of New York." In 1879 there was a paper stating that "a very large proportion of the adulterations practiced are not attempts at fraud, nor designed to damage health, but are strained efforts to make money. And these efforts are so earnest and so intense, energetic and absorbing as to leave all other considerations in the background."

All federal food-control legislation is based upon the taxing power of the federal government, or its power to regulate foreign commerce, or its power to regulate commerce between various states. A federal law was passed in 1886 placing a tax upon oleomargarine and regulating its sale. This was amended in 1902. Whatever usefulness this law had when first enacted, conditions have so changed subsequently that from an asset the law changed to a liability. In 1950 the law was changed to fit the times. In 1896 the law regulating the taxing of filled cheese was enacted, and 1898 a mixed-flour law was passed. The application of that clause of the Constitution which gives the federal government power to regulate foreign commerce was invoked as early as 1848 for the control of imported drugs. In 1890 a very general law was passed relating to exported and imported foods, but no special provision was made for its enforcement. In 1897 a law relating to the importation of tea was passed and an effective control established. In 1900, the Bureau of Chemistry of the Department of Agriculture was given authority to examine imported shipments of foods and to exclude from the country such shipments offered for entry as were adulterated or misbranded. A meat inspection law was passed in 1891, but this law was not very effective and meat inspection did not become so until 1906 when the Federal Pure Food and Drugs Act was passed and became effective January 1, 1907. This act served splendidly in spite of the many controversies which grew around it. But our country continued to grow, and with it grew the techniques of food production and preservation, and also drug and cosmetic manufacture. Needs for changes in the Federal Law became apparent some years ago. After many years of the governments' struggle with the representatives of the food industry a compromise law was passed in 1938. The newly amended Federal Food, Drug, and Cosmetic Act was a decided improvement over the old law but left much to be desired. This law is now administered by the Department of Health, Education, and Welfare. An important amendment to the latter law, Public Law 85-929 known as the Food Additive Amendment, was passed Sept. 6, 1958 and became fully effective on March 9, 1959.

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*The History of a Crime against the Food Law. H. W. Wiley.

In 1962 the Federal Food, Drug, and Cosmetic Act was amended and much improved over all past food control laws. It particularly put the onus on the manufacturers of drugs to prove their products' effectiveness and degree of freedom from injurious consequences. The 1965 amendment attempts to control the abuse in the traffic of stimulant and depressant drugs.

Drug Abuse Control Amendments (Of the Federal Food, Drug, and Cosmetic Act) of 1965, (Public Law 89-74)

No person shall manufacture compound, process, or otherwise use any depressant or stimulant drug, except that this prohibition shall not apply to the following who are registered or licensed and regularly engaged and otherwise qualified: Manufacturers, compounders, processors, suppliers of manufacturers, of compounders, and of processors, wholesale druggists, pharmacists, hospitals, clinics, public health agencies, practitioners licensed by law, researchers, teachers, analyzers, officers and employees of the United States, of a State government, or of a political subdivision of a State, an employee or agent under the supervision of a practitioner.

No person other than the above listed and those qualified as common or contract carriers, warehousemen, or an employee of those whose possession of these drugs is in the usual course of business or employment shall sell, deliver, or otherwise dispose of any depressant or stimulant drug to any other person.

No person other than those described above shall possess any depressant or stimulant drug otherwise than for personal use of himself or a member of his household, or for administration to an animal owned by him or a member of his household, the burden of proof for violation being on the United States.

Every person engaged in manufacturing, compounding, processing, selling, delivering, or otherwise disposing of any depressant or stimulant drug shall prepare a complete and accurate record of all stocks on hand, handled, and disposed of, shall keep such records for 3 years, and shall permit inspection of same by an officer of the government. The provisions for record keeping and inspection shall not apply to a licensed practitioner for such drugs received, prepared, processed, administered, or dispensed by him in the course of his professional practice, unless he regularly engages in dispensing any such drugs to his patients for which they are charged, either separately or together with charges for other professional services.

No prescription for any depressant or stimulant drug may be filled or refilled more than six months after date on which prescription was issued nor be refilled more than 5 times except when renewed in writing or orally by the practitioner.

Definitions

The term "food" means (1) articles used for food or drink for man or other animals, (2) chewing gum, and (3) articles used for components of any such article.

The term "drug" means (1) articles recognized in the official United States Pharmacopeia, official Homoeopathic Pharmacopoeia of the United States, or official National Formulary, or any supplement to any of them; and (2) articles intended for use in the diagnosis, cure mitigation, treatment, or prevention of disease in man or other animals; and (3) articles (other than food) intended to affect the structure or any function of the body of man or other animals; and (4) articles intended for use as a component of any articles specified in clause (1), (2), or (3) of this definition; but does not include devices or their components, parts, or accessories.

The term "device" means instruments, apparatus, and contrivances, including their components, parts, and accessories, intended (1) for use in the diagnosis, cure, mitigation, treatment or prevention of disease in man or other animals; or (2) to affect the structure or any function of the body of man or other animals.

The term "cosmetic" means (1) articles intended to be rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to the human body or any part thereof for cleansing, beautifying, promoting attractiveness, or altering the appearance, and (2) articles intended for use as a component of any such articles; except that such term shall not include soap.

The term "label" means a display of written, printed, or graphic matter upon the immediate container of any article; and a requirement made by or under authority of this Act that any word, statement, or other information appearing on the label shall not be considered to be complied with unless such word, statement, or other information also appears on the outside container or wrapper, if any there be, of the retail package of such article, or is easily legible through the outside container or wrapper.

The term "labeling" means all labels and other written, printed, or graphic matter (1) upon any article or any of its containers or wrappers, or (2) accompanying such article.

The term "official compendium" means the official United States Pharmacopeia, official Homoeopathic Pharmacopoeia of the United States, official National Formulary, or any supplement to any of them.

Prohibited Acts

Sec. 301. The following acts and the causing thereof are hereby prohibited:

a. The introduction or delivery for introduction into interstate commerce of any food, drug, device, or cosmetic that is adulterated or misbranded.

b. The adulteration or misbranding of any food, drug, device, or cosmetic in interstate commerce.

c. The receipt in interstate commerce of any food, drug, device, or cosmetic that is adulterated or misbranded, and the delivery or proffered delivery thereof for pay or otherwise.

d. The introduction or delivery for introduction into interstate commerce of any article in violation of section on "Emergency Permit Control" or on "New Drugs".

e. The refusal to permit access to or copying of any record as required by Section on "Records on Interstate Shipment"; or failure to establish or maintain any record, or make any report, required under section on "New Drugs", or section on "Certification of Antibiotics", or the refusal to permit access to or verification or copying of any such required record.

f. The refusal to permit entry or inspection as authorized.

g. The manufacture within any Territory of any food, drug, device, or cosmetic that is adulterated or misbranded.

h. The giving of a guaranty or undertaking referred to in section on "Penalties", which guaranty or undertaking is false, except by a person who relied upon a guaranty or undertaking to the same effect signed by, and containing the name and address of, the person residing in the United States from whom he received in good faith the food, drug, device, or cosmetic; or the giving of a guaranty or undertaking referred to in section on "Penalties", which guaranty or undertaking is false.

i. Forging, counterfeiting, simulating, or falsely representing, or without proper authority using any mark, stamp, tag, label, or other identification device authorized or required by regulations promulgated under the provisions of sections on "Emergency Permit Control", "Certification of Drugs Containing Insulin", "Certification of Antibiotics", or "Listing Certification of Color Additives for Food, Drugs, and Cosmetics".

j. The using by any person to his own advantage, or revealing, other than to the Secretary or officers or employees of the Department, or to the courts when relevant in any judicial proceeding under this Act, any information acquired under authority of this law concerning any method or process which as a trade secret is entitled to protection.

k. The alteration, mutilation, destruction, obliteration, or removal of the whole or any part of the labeling of, or the doing of any other act with respect to, a food, drug, device, or cosmetic, if such act is done while such article is held for sale (whether or not the first sale) after shipment in interstate commerce and results in such article being adulterated or

misbranded.

l. The using, on the labeling of any drug or in any advertising relating to such drug, of any representation or suggestion that approval of an application with respect to such drug is in effect, or that such drug complies with the provisions of this law.

m. The sale or offering for sale of colored oleomargarine or colored margarine, or the possession or serving of colored oleomargarine or colored margarine in violation of the law.

n. The using, in labeling, advertising or other sales promotion of any reference to any report or analysis furnished in compliance with section on "Factory Inspection".

o. In the case of a prescription drug distributed or offered for sale in interstate commerce, the failure of the manufacturer, packer, or distributor thereof to maintain for transmittal, or to transmit, to any practitioner licensed by applicable State law to administer such drug who makes written request for information as to such drug, true and correct copies of all printed matter which is required to be included in any package in which that drug is distributed or sold, or such other printed matter as is approved by the Secretary. Nothing in this paragraph shall be construed to exempt any person from any labeling requirement imposed by or under other provisions of this Act.

p. The failure to register as required by section on "Registration of Producers of Drugs".

Injunction Proceedings

Sec. 302. a. The district courts of the United States and the United States courts of the Territories shall have jurisdiction, for cause shown, and subject to the provisions of section on "Relating To Notice To Opposite Party," to restrain violations of section 301 relating to "Prohibited Act," except paragraphs (h), (i), and (j) of the latter.

b. In case of violation of an injunction or restraining order issued under this section, which also constitutes a violation of this Act, trial shall be by the court, or, upon demand of the accused, by a jury.

Seizure

Section 304. a. Any article of food, drug, device, or cosmetic that is adulterated or misbranded when introduced into or while in interstate commerce or while held for sale (whether or not the first sale) after shipment in interstate commerce, or which may not be introduced into interstate commerce, shall be liable to be proceeded against while in interstate commerce, or at any time thereafter, on libel of information and condemned in any district court of the United States within the jurisdiction of which the article is found: Provided, however, That no libel for condemnation shall be instituted under this Act, for any alleged misbranding if there is pending in any court a libel for condemnation proceeding under this Act based upon the same alleged misbranding, and not more than one such proceeding shall be instituted if no such proceeding is so pending, except that such limitations shall not apply (1) when such misbranding has been the basis of a prior judgment in favor of the United States, in a criminal, injunction, or libel for condemnation proceeding under this Act, or (2) when the Secretary has probable cause to believe from facts found, without hearing, by him or any officer or employee of the Department that the misbranded article is dangerous to health, or that the labeling of this misbranded article is fraudulent, or would be in a material respect misleading to the injury or damage of the purchaser or consumer.

b. The article shall be liable to seizure by process pursuant to the libel, and the procedure in cases shall conform, as nearly as may be, to the procedure in admiralty; except that on demand of either party any issue of fact joined in any such case shall be tried by jury.

c. The court at any time after seizure up to a reasonable time before trial shall by order allow any party to a condemnation proceeding, his attorney or agent, to obtain a representative sample of the article seized and a true copy of the analysis, if any, on which the proceeding is based and the identifying marks or numbers, if any, of the packages from which the samples analyzed were obtained.

d. Any food, drug, device, or cosmetic condemned under this section shall, after entry of the decree, be disposed of by destruction or sale as the court may, in accordance with the provisions of the law, direct and the proceeds thereof, if sold, less the legal costs and charges, shall be paid into the Treasury of the United States; but such article shall not be sold under such decree contrary to the provisions of this Act or the laws of the jurisdiction in which sold: Provided, That after entry of the decree and upon the payment of the costs of such proceedings and the execution of a good and sufficient bond conditioned that such article shall not be sold or disposed of contrary to the provisions of this Act or the laws of any State or Territory in which sold, the court may by order direct that such article be delivered to the owner thereof to be destroyed or brought into compliance with the provisions of this Act under the supervision of an officer or employee duly designated by the Secretary, and the expenses of such supervision shall be paid by the person obtaining release of the article under bond. If the article was imported into the United States and the person seeking its release established (1) that the adulteration, misbranding, or violation did not occur after the article was imported, and (2) that he had no cause for believing that it was adulterated, misbranded, or in violation before it was released from customs custody, the court may permit the article to be delivered to the owner for exportation in lieu of destruction upon a showing by the owner that all of the conditions can and will be met.

e. When a decree of condemnation is entered against the article, court costs and fees, and storage and other proper expenses, shall be awarded against the person, if any, intervening as claimant of the article.

Hearing Before Report of Criminal Violation

Sec. 305. Before any violation of this Act is reported by the Secretary to any United States attorney for institution of a criminal proceeding, the person against whom such proceeding is contemplated shall be given appropriate notice and an opportunity to present his views, either orally or in writing, with regard to such contemplated proceeding.

a. Presentation of views shall be private and informal.

Report of Minor Violations

Sec. 306. Nothing in this Act shall be construed as requiring the Secretary to report for prosecution, or for the institution of libel or injunction proceedings, minor violations of this Act whenever he believes that the public interest will be adequately served by a suitable written notice or warning.

Proceedings in Name of United States; Provision as to Subpoenas

Sec. 307. All such proceedings for the enforcement, or to restrain violations, of this Act shall be by and in the name of the United States. Subpoenas for witnesses who are required to attend a court of the United States, in any district, may run into any other district in any such proceeding.

Definitions and Standards for Food

Sec. 401. Whenever in the judgment of the Secretary such action will promote honesty and fair dealing in the interest of consumers, he shall promulgate regulations fixing and establishing for any food, under its common or usual name so far as practicable, a reasonable definition and standard of identity, a reasonable standard of quality, and/or reasonable standards of fill of container: Provided, That no definition and standard of identity and no standard of quality shall be established for fresh or dried fruits, fresh or dried vegetables, or butter, except that definitions and standards of identity may be established for avocados, cantaloupes, citrus fruits, and melons.

Adulterated Food

Sec. 402. A food shall be deemed to be adulterated:

(1) If it bears or contains any poisonous or deleterious substance which may render it injurious to health; but in case the substance is not an added substance such food shall not be considered adulterated under this clause if the quantity of such substance in such food does not ordinarily render it injurious to health; or

(2) if it bears or contains any added poisonous or added deleterious substance (other than one which is (i) a pesticide chemical in or on a raw agricultural commodity; (ii) a food additive; or (iii) a color additive which is unsafe, or if it is a raw agricultural commodity and it bears or contains a pesticide chemical which is unsafe, or if it is, or it bears or contains, any food additive which is unsafe: Provided, That where a pesticide chemical has been used in or on a raw agricultural commodity in conformity with an exemption granted or a tolerance prescribed and such raw agricultural commodity has been subjected to processing such as canning, cooking, freezing, dehydrating, or milling, the residue of such pesticide chemical remaining in or on such processed food shall not be deemed unsafe if such residue in or on the raw agricultural commodity has been removed to the extent possible in good manufacturing practice and the concentration of such residue in the processed food when ready to eat is not greater than the tolerance prescribed for the raw agricultural commodity; or

(3) if it consists in whole or in part of any filthy, putrid, or decomposed substance, or if it is otherwise unfit for food; or if it has been prepared, packed, or held under insanitary conditions whereby it may have become contaminated with filth, or whereby it may have been rendered injurious to health; or if it is, in whole or in part, the product of a diseased animal or of an animal which has died otherwise than by slaughter; or if its container is composed, in whole or in part, of any poisonous or deleterious substance which may render the contents injurious to health; or if it has been intentionally subjected to radiation, unless the use of the radiation was in conformity with a regulation or exemption in effect pursuant to section on "Food Additives," or

(4) if any valuable constituent has been in whole or in part omitted or abstracted therefrom; or if any substance has been substituted wholly or in part therefor; or if damage or inferiority has been concealed in any manner; or if any substance has been added thereto or mixed or packed therewith so as to increase its bulk or weight, or reduce its quality or strength, or make it appear better or of greater value than it is.

(5) if it is, or it bears or contains, a color additive which is unsafe;

(6) if it is confectionery, and it bears or contains any alcohol or non-nutritive article or substance except authorized coloring, harmless flavoring, harmless resinous glaze not in excess of four-tenths of 1 per centum, natural gum, and pectin: Provided, That this paragraph shall not apply to any confectionery by reason of its containing less than one-half of 1 per centum by volume of alcohol derived solely from the use of flavoring extracts, or to any chewing gum by reason of its containing harmless non-nutritive masticatory substances.

(7) if it is oleomargarine or margarine or butter and any of the raw material used therein consisted in whole or in part of any filthy, putrid, or decomposed substance, or such oleomargarine or margarine or butter is otherwise unfit for food.

Sec. 403. A food shall be deemed to be misbranded:

(1) If its labeling is false or misleading in any particular.

(2) If it is offered for sale under the name of another food.

(3) If it is an imitation of another food, unless its label bears, in type of uniform size and prominence, the word "imitation" and, immediately thereafter, the name of the food imitated.

(4) If its container is so made, formed, or filled as to be misleading;

(5) If in package form unless it bears a label containing the name and place of business of the manufacturer, packer, or distributor; and an accurate statement of the quantity of the contents in terms of weight, measure, or numerical count: Provided, That, under the latter clause of this paragraph, reasonable variations shall be permitted, and exemptions as to small packages shall be established, by regulations prescribed by the Secretary.

(6) If any word, statement, or other information required by or under authority of this Act to appear on the label or labeling is not prominently placed thereon with such conspicuousness (as compared with other words, statements, designs, or devices, in the labeling) and in such terms as to render it likely to be read and understood by the ordinary individual under customary conditions of purchase and use.

(7) If it purports to be or is represented as a food for which a definition and standard of identity has been prescribed by regulations unless it conforms to such definition and standard, and its label bears the name of the food specified in the definition and standard, and, insofar as may be required by such regulations, the common names of optional ingredients (other than spices, flavoring, and coloring) present in such food.

(8) If it purports to be or is represented as:

a. a food for which a standard of quality has been prescribed by regulations, and its quality falls below such standard, unless its label bears, in such manner and form as such regulations specify, a statement that it falls below such standard; or

b. a food for which a standard or standards of fill of container have been prescribed by regulations, and it falls below the standard of fill of container applicable thereto, unless its label bears, in such manner and form as such regulations specify, a statement that it falls below such standard.

(9) If it is not subject to the provisions relating to "definition and standard of identity" of this section unless its label bears the common or usual name of the food, if any there be, and in case it is fabricated from two or more ingredients, the common or usual name of each such ingredient; except that spices, flavorings, other than those sold as such, may be designated as spices, flavorings, and colorings without naming each: Provided, That, to the extent that compliance with the requirements of the latter clause of this paragraph is impracticable, or results in deception or unfair competition, exceptions shall be established by regulations promulgated by the Secretary.

(10) If it purports to be or is represented for special dietary uses, unless its label bears such information concerning its vitamin, mineral, and other dietary properties as the Secretary determines to be, and by regulations, prescribes as, necessary in order fully to inform purchasers as to its value for such uses.

(11) If it bears or contains any artificial flavoring, artificial coloring, or chemical preservative, unless it bears labeling stating that fact: Provided, That to the extent that compliance with the requirements of this paragraph is impracticable, exemptions shall be established by regulations promulgated by the Secretary. The provisions of this paragraph and paragraphs (7) and (9) with respect to artificial coloring shall not apply in the case of butter, cheese, or ice cream. The provisions of this paragraph with respect to chemical preservatives shall not apply to a pesticide chemical when used in or on a raw agricultural commodity which is the produce of the soil.

(12) If it is a raw agricultural commodity which is the produce of the soil, bearing or containing a pesticide chemical applied after harvest, unless the shipping container of such commodity bears labeling which declares the presence of such chemical in or on such commodity and the common or usual name and the function of such chemical: Provided, however, That no such declaration shall be required while such commodity, having been removed from the shipping container, is being held or displayed for sale at retail out of such container in accordance with the custom of the trade. (Nothing in the amendments made by the first section of this Act 403 (11) and(12)) shall affect any requirement of the laws of any State or Territory.)

(13) If it is a color additive, unless its packaging and labeling are in conformity with such packaging and labeling requirements, applicable to such color additive, as may be contained in regulations issued under section on "Listing and Certification of Color Additives for Foods, Drugs, and Cosmetics".

Emergency Permit Control

Sec. 404 (a) Whenever the Secretary finds after investigation that the distribution in interstate commerce of any class of food may, by reason of contamination with microorganisms during the manufacture, processing, or packaging thereof in any locality, be injurious to health, and that such injurious nature cannot be adequately determined after such articles have entered interstate commerce, he then, and in such case only, shall promulgate regulations providing for the issuance, to manufacturers, processors, or packers of such class of food in such locality, of permits to which shall be attached such conditions governing the manufacture, processing, or packing of such class of food, for such temporary period of time, as may be necessary to protect the public health; and after the effective date of such regulations, and during such temporary period, no person shall introduce or deliver for introduction into interstate commerce any such food manufactured, processed, or packed by any such manufacturer, processor, or packer unless such manufacturer, processor, or packer holds a permit issued by the Secretary as provided by such regulations.

(b) The Secretary is authorized to suspend immediately upon notice any permit issued under authority of this section if it is found that any of the conditions of the permit have been violated. The holder of a permit so suspended shall be privileged at any time to apply for the reinstatement of such permit, and the Secretary shall, immediately after prompt hearing and an inspection of the establishment, reinstate such permit if it is found that adequate measures have been taken to comply with and maintain the conditions of the permit, as originally issued or as amended.

(c) Any officer or employee duly designated by the Secretary shall have access to any factory or establishment, the operator of which holds a permit from the Secretary, for the purpose of ascertaining whether or not the conditions of the permit are being complied with, and denial of access for such inspection shall be ground for suspension of the permit until such access is freely given by the operator.

Regulations Making Exemptions

Sec. 405. The Secretary shall promulgate regulations exempting from any labeling requirement of this Act (1) small open containers of fresh fruits and fresh vegetables and (2) food which is, in accordance with the practice of the trade, to be processed, labeled, or repacked in substantial quantities at establishments other than those where originally processed or packed, on condition that such food is not adulterated or misbranded under the provisions of this Act upon removal from such processing, labeling, or repacking establishment.

Tolerances for Poisonous Ingredients in Food

Sec. 406. Any poisonous or deleterious substance added to any food, except where such substance is required in the production thereof or cannot be avoided by good manufacturing practice shall be deemed to be unsafe (adulterated); but when such substance is so required or cannot be so avoided, the Secretary shall promulgate regulations limiting the quantity therein or thereon to such extent as he finds necessary for the protection of public health, and any quantity exceeding the limits so fixed shall also be deemed to be unsafe (adulterated). While such a regulation is in effect limiting the quantity of any such substance in the case of any food, such food shall not, by reason of bearing or containing any added amount of such substance, be considered to be adulterated. In determining the quantity of such added substance to be tolerated in or on different articles of food, the Secretary shall take into account the extent to which the use of such substance is required or cannot be avoided in the production of each such article, and the other ways in which the consumer may be affected by the same or other poisonous or deleterious substances.

Oleomargarine or Margarine

(Public Law 459 -- 81st Congress -- March 16, 1950 (64 Stat. 20), amended section 15 of the Federal Trade Commission Act, as Amended, by adding at the end thereof the following new subsections: "(f) For the purposes of this section and section 407 of the Federal Food, Drug, and Cosmetic Act, As Amended, the term 'oleomargarine' or 'margarine' includes-- (1) all substances, mixtures, and compounds known as oleomargarine or margarine; (2) all substances, mixtures, and compounds which have a consistence similar to that of butter and

which contain any edible oils or fats other than milk fat if made in imitation or semblance of butter."

Sec. 407. (a) Colored oleomargarine or colored margarine which is sold in the same State or Territory in which it is produced shall be subject in the same manner and to the same extent to the provisions of this act as if it had been introduced in interstate commerce.

(b) No person shall sell, or offer for sale, colored oleomargarine or colored margarine unless:

(1) such oleomargarine or margarine is packaged,

(2) the net weight of the contents of any package sold in a retail establishment is one pound or less,

(3) there appears on the label of the package the word "oleomargarine" or "margarine" in type or lettering at least as large as any other type of lettering on such label, and a full and accurate statement of all the ingredients contained in such oleomargarine, or margarine, and

(4) each part of the contents of the package is contained in a wrapper which bears the word "oleomargarine" or "margarine" in type or lettering not smaller than 20-point type.

The requirements of this subsection shall be in addition to and not in lieu of any of the other requirements of this Act.

(c) No person shall possess in a form ready for serving colored oleomargarine or colored margarine at a public eating place unless a notice that oleomargarine or margarine is served, be displayed prominently and conspicuously in such place and in such manner as to render it likely to be read and understood by the ordinary individual being served in such eating place,or is printed or is otherwise set forth on the menu in type or lettering not smaller than that normally used to designate the serving of other food items. No person shall serve colored oleomargarine or colored margarine at a public eating place, whether or not any charge is made therefor, unless each separate serving bears or is accompanied by labeling identifying it as oleomargarine or margarine, or each separate serving thereof is triangular in shape.

(d) Colored oleomargarine or colored margarine when served with meals at a public eating place shall at the time of such service be exempt from the labeling requirements of section 403 (except (a) and (f) if it complies with the requirements of subsection (b) of this section).

(e) For the purpose of this section, colored oleomargarine or colored margarine is oleomargarine or margarine having a tint or shade containing more than one and six-tenths degrees of yellow, or of yellow and red collectively, but with an excess of yellow over red, measured in terms of Lovibond tintometer scale or its equivalent.

Tolerances for Pesticide Chemicals in or on Raw Agricultural Commodities

Sec. 408. (a) Any poisonous or deleterious pesticide chemical, or any pesticide chemical which is not generally recognized, among experts qualified by scientific training and experience to evaluate the safety of pesticide chemicals, as safe for use, added to a raw agricultural commodity, shall be deemed unsafe unless:

(1) a tolerance for such pesticide chemical in or on the raw agricultural commodity has been prescribed by the Secretary of Health, Education, and Welfare and the quantity of such pesticide chemical in or on the raw agricultural commodity is within the limits of the tolerance so prescribed; or

(2) with respect to use in or on such raw agricultural commodity, the pesticide chemical has been exempted from the requirement of a tolerance by the Secretary.

While a tolerance or exemption from tolerance is in effect for a pesticide chemical with

respect to any raw agricultural commodity, such raw agricultural commodity shall not, by reason of bearing or containing any added amount of such pesticide chemical, be considered to be adulterated.

(b) The Secretary shall promulgate regulations establishing tolerances with respect to the use in or on raw agricultural commodities of poisonous or deleterious pesticide chemicals and of pesticide chemicals which are not generally recognized, among experts qualified by scientific training and experience to evaluate the safety of pesticide chemicals, as safe for use, to the extent necessary to protect the public health. In establishing any such regulation, the Secretary shall give appropriate consideration, among other relevant factors, (1) to the necessity for the production of an adequate, wholesome, and economical food supply; (2) to the other ways in which the consumer may be affected by the same pesticide chemical or by other related substances that are poisonous or deleterious; and (3) to the opinion of the Secretary of Agriculture as submitted with a certification of usefulness. In carrying out the provisions relating to the establishment of tolerances, the Secretary may establish the tolerance applicable with respect to the use of any pesticide chemical in or on any raw agricultural commodity at zero level if the scientific data before the Secretary does not justify the establishment of a greater tolerance.

(c) The Secretary shall promulgate regulations exempting any pesticide chemical from the necessity of a tolerance with respect to use in or on any or all raw agricultural commodities when such a tolerance is not necessary to protect the public health.

Food Additives

Sec. 409 (a) A food additive shall, with respect to any particular use or intended use of such additives, be deemed to be unsafe, unless:

(1) it and its use or intended use conform to the terms of an exemption which is in effect, or

(2) there is in effect, and it and its use or intended use are in conformity with, a regulation issued prescribing the conditions under which such additive may be safely used.

While such a regulation relating to a food additive is in effect, a food shall not, by reason of bearing or containing such an additive in accordance with the regulations, be considered adulterated.

New Drugs

Sec. 505. (a) No person shall introduce or deliver for introduction into interstate commerce any new drug, unless an approval of an application is effective with respect to such drug.

(b) Any person may file with the Secretary an application with respect to any drug. Such persons shall submit to the Secretary as a part of the application (1) full reports of investigations which have been made to show whether or not such drug is safe for use and whether such drug is effective in use; (2) a full list of the articles used as components of such drug; (3) a full statement of the composition of such drug; (4) a full description of the methods used in, and the facilities and controls used for, the manufacture, processing and packing of such drug; (5) such samples of such drug and of the articles used as components thereof as the Secretary may require; and (6) specimens of the labeling proposed to be used for such drug.

(d) If the Secretary finds, after due notice to the applicant and giving him an opportunity for a hearing, that (1) the investigations, reports of which are required to be submitted to the Secretary do not include adequate tests by all methods reasonably applicable to show whether or not such drug is safe for use under conditions prescribed, recommended, or suggested in the proposed labeling thereof; (2) the results of such tests show that such drug is unsafe for use under such conditions or do not show that such drug is safe for use under such conditions; (3) the methods used in, and the facilities and controls used for, the manufacture, processing, and packing of such drug are inadequate to preserve its identity, strength, quality, and purity; (4) upon the basis of the information submitted to him as part of the application, or upon the basis of any other information before him with respect to such drug, he has insufficient information to determine whether such drug is safe for use under such conditions; or (5) evaluated

on the basis of the information submitted to him as part of the application and any other information before him with respect to such drug, there is a lack of substantial evidence that the drug will have the effect it purports or is represented to have under the conditions of use prescribed, recommended, or suggested in the proposed labeling thereof; or (6) based on a fair evaluation of all material facts, such labeling is false or misleading in any particular; he shall issue an order refusing to approve the application. If, after such notice and opportunity for hearing, the Secretary finds that clauses (1) through (6) do not apply, he shall issue an order approving the application. The term "substantial evidence" means evidence consisting of adequate and well-controlled investigations, including clinical investigations, by experts qualified by scientific training and experience to evaluate the effectiveness of the drug involved, on the basis of which it could fairly and responsibly be concluded by such experts that the drug will have the effect it purports or is represented to have under the conditions of use prescribed, recommended, or suggested in the labeling or proposed labeling thereof.

(e) The Secretary shall, after due notice and opportunity for hearing to the applicant, withdraw approval of an application with respect to any drug if the Secretary finds (1) that clinical or other experience, tests, or other scientific data show that such drug is unsafe for use under the conditions of use upon the basis of which the application was approved; (2) that new evidence of clinical experience, not contained in such application or not available to the Secretary until after such application was approved, or tests by new methods, or tests by methods not deemed reasonably applicable when such application was approved, evaluated together with the evidence available to the Secretary when the application was approved, shows that such drug is not shown to be safe for use under the conditions of use upon the basis of which the application was approved; or (3) on the basis of new information before him with respect to such drug, evaluated together with the evidence available to him when the application was approved, that there is a lack of substantial evidence that the drug will have the effect it purports or is represented to have under the conditions of use prescribed, recommended, or suggested in the labeling thereof; or (4) that the application contains any untrue statement of a material fact: Provided, That if the Secretary (or in his absence the officer acting as Secretary) finds that there is an imminent hazard to the public health, he may suspend the approval of such application immediately, and give the applicant prompt notice of his action and afford the applicant the opportunity for an expedited hearing under this subsection; but the authority conferred by this proviso to suspend the approval of an application shall not be delegated.

Registration of Producers of Drugs

The Congress hereby finds and declares that in order to make regulation of interstate commerce in drugs effective, it is necessary to provide for registration and inspection of all establishments in which drugs are manufactured, prepared, propagated, compounded, or processed; that the products of all such establishments are likely to enter the channels of interstate commerce and directly affect such commerce; and that the regulation of interstate commerce in drugs without provision for registration and inspection of establishments that may be engaged only in intrastate commerce in such drugs would discriminate against and depress interstate commerce in such drugs, and adversely burden, obstruct, and affect such interstate commerce.

On or before December 31 of each year every person who owns or operates any establishment in any State engaged in the manufacture, preparation, propagation, compounding, or processing of a drug or drugs shall register with the Secretary his name, places of business, and all such establishments.

Regulations and Hearing

Sec. 701. (a) The authority to promulgate regulations for the efficient enforcement of this Act, except as otherwise provided, is hereby vested in the Secretary.

(b) Hearings authorized or required by this Act shall be conducted by the Secretary or such officer or employee as he may designate for this purpose.

Preservation of Food. The preservation of meat, milk, vegetables and other perishable foods is one of the important questions we have to deal with in public health. The proper preservation of food stuffs involves not only the art of keeping them "fresh" and wholesome, but

also keeping them so that they will not lose their nutritive value, and will not acquire injurious properties. The preservatives ordinarily in use are: cold, drying, salting, smoking, canning, preserving, chemical treatment, fermentation, and physical processes. Practically all these methods have long been in use. The only modern innovation in the preservation of foods is in the perfection of old processes, and the use of mechanical means, such as vacuum, filtration, pressure, radiation, etc.

The art of preserving foods successfully is largely a problem in applied bacteriology. The chief mischief has been the threat of a blind use of chemical germicide without regard for their effect upon health. The Federal Pure Food and Drugs Act of 1906 was passed largely to meet this situation.

Refrigeration and Freezing. Cold prevents bacteria from growing and prevents the action of enzymes which cause ripening. Cold may kill the weak bacteria and therefore low temperature refrigeration may reduce the amount of bacteria in a particular material. Some animal parasites die in cold storage. Thus, trichinae die at or below 5°F. in less than 20 days, Taenia saginata (beef tapeworm) die within 6 days at 15°F. Accepted refrigeration treatment for destroying trichinae is 5°F. for 20 to 30 days depending on thickness of meat, or -10°F. for 10 to 20 days, or -20°F. for 6 to 12 days. The best temperature at which foodstuffs may be kept must be determined in each case. Some substances, such as meat, fish and poultry are better preserved when actually frozen, other, such as shell-eggs, milk, potatoes, oranges are more easily injured by freezing. Frozen food should be consumed within a few hours after defrosting. The temperature of household ice boxes should not rise above 7°C. or 45°F. Cold storage temperatures must be below freezing. From the sanitary standpoint, refrigeration is one of the best methods of preserving foodstuffs. It neither detracts from or adds to the taste, nutrition, digestibility and at the same time prevents decomposition and bacterial growth.

Although the freezing of foods for commerical use began as early as 1842, when H. Benjamin was granted a patent for freezing foods by immersion in an ice and salt brine, the large scale use of the freezing process for perishable foods began in the 1920's. A perishable food may be considered one which spoils rapidly as a result of bacterial action, or enzymic action, or both. Most fruits, vegetables, and meats are amenable to the quick-freezing process, except such as lettuce, cucumbers, celery, and tomatoes. Root vegetables and tubers usually do not require freezing to remain edible for long periods. Slow-freezing causes the thawed food to take on undesirable characteristics of color, freshness, and moisture content. The fact that it is more difficult to subject some foods to the freezing process and that some will take freezing well at one time and poorly at another time is probably due to lack of knowledge. The behavior of food to freezing is greatly effected by the history of the products during growing and handling: to wit: the nature of the seed, the character of the soil, the climate, the stage of harvesting, and the handling before freezing.

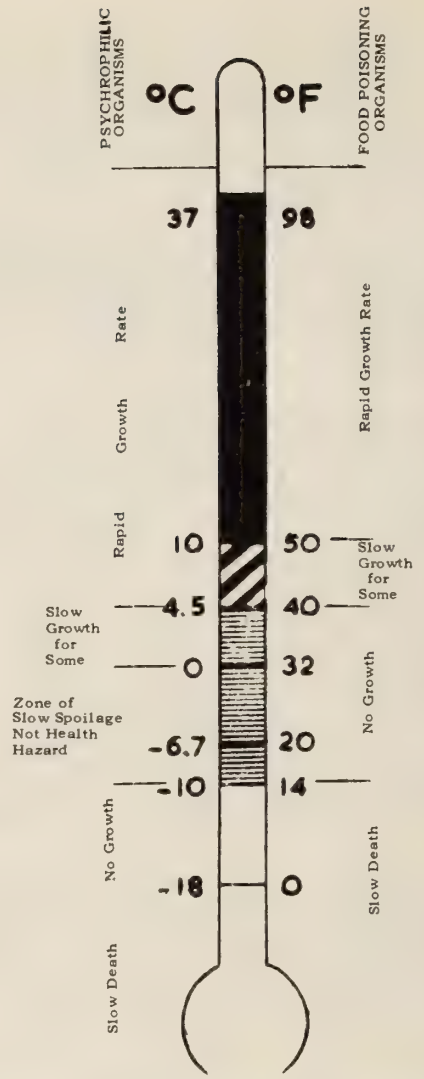
Bacterial and enzymic action are greatly reduced by freezing, and both are readily destroyed by heat. Therefore the process of scalding certain fruits and vegetables prior to freezing is practiced. There is accumulating evidence that freezing is not only bacteriostatic but also bactericidal to some extent. The scalding may, however, leach out small to moderate quantities of protein, sugar, minerals and vitamin C. The vitamin content of fruits and vegetables are lowered by long periods of storage. The higher the storage temperature the quicker the vitamin loss, particularly vitamins A and C. When taken from freezing units, the prompt and proper cooking of food will bring the fresh qualities of the food to the table. Thawed food makes it a much better medium for bacterial growth than before freezing. The refreezing of foods that have been thawed may cause changes in taste, odor, color or texture.

Bacterial standards for frozen food have not yet been satisfactorily developed for official acceptance, therefore the sanitation of handling and processing techniques must be relied upon.

Frozen Foods in Adverse Temperature Conditions*

The natural growth characteristics of bacteria provide a built-in protection for frozen foods. First, there is some destruction of bacteria by freezing, but this is not great. Then, there is a delay of growth of bacteria, even in thawed foods while they adjust to their new environment, and finally, logarithmic growth is very slow while held at low temperatures. Frozen foods are no more of a public health hazard than any other type of food.

Frozen food can be preserved for long periods of time. At elevated temperatures, as can be seen in the following tables, protracted periods of time may be necessary to produce signs of the "first detectable" changes in quality of a product as determined by a trained taste panel or by physical and chemical tests. This is sooner than the average consumer could detect a change.



Temperature in Relation to Bacterial Growth and Death

Figure 1

Table 14

Approximate Storage Periods for General Classes of Frozen Food at 0°F. Without Their Showing Any Appreciable Quality Loss	
Chicken (well packaged), heat treated citrus concentrates, poultry pies, and fruit pies	Over 1 year
Most fruits, vegetables and juices, confections, beef, veal, lamb, turkeys, meat pies, and some fish	10 months to 1 year
Pork, most dairy products, shellfish and some fatty fish	8 to 10 months
Fried foods, most bakery products, and very fatty fish	6 months or less
Holding temperatures of above 0°F. for frozen foods accelerates the speed of quality changes, as would be expected of any biological material.	

* Walter A. Maclinn, Sanitarians Journal of Environmental Health, Vol. 25, No. 1, pages 15-19, 1962.

Table 15

Periods of Time at Various Temperatures of Product That Give Approximately Equivalent Effects on Quality Loss for a Broad Class of Fruits and Vegetables

Temperature	Sensitive Fruits and Vegetables*
0°F.	1 year
5°F.	5 months
10°F.	6 weeks
15°F.	3 weeks
20°F.	1 week
25°F.	2 days
30°F.	1 day

* Where discoloration occurs, such as in peaches and cauliflower.

Table 16

Periods of Time at Various Temperatures of Product That Give Approximately Equivalent Effects on Quality Loss for Baker Products

Temperature	For Bread and for Other Bakery Products
0°F.	10 weeks or more
10°F.	5 weeks approx.
15°F.	2 weeks approx.

When a frozen product is exposed to elevated temperatures, there is a natural temperature lag due to the coefficient of heat transfer. This rate of heat transfer is influenced by the air temperature, the number of pieces stacked together, the degree of air circulation between pieces, the type of casing material, the number of individual packages within the case, and the density of the product itself.

Most frozen fruits, vegetables, juice concentrate and fruit and meat pies, in retail packages and in standard cases, have approximately the same coefficient of heat transfer when exposed to elevated temperatures. Typical of the reaction of the corner package of a single case of retail sale frozen foods when exposed to elevated temperatures, is as follows:

Table 17

Average Temperature of Corner Package of Single Case Standing in Air at 65°F.

Initial Temperature °F.	°F. Temperature after: ½ hour	1 hour	2 hours	4 hours
0	4	6	10	16
10	12	14	16	19
15	16	18	20	23

From these data it can be seen that frozen foods exposed to the adverse temperature conditions in the marketing channel from producer to consumer, do not lose their quality under normal handling conditions. If mishandling occurs it has to be of a rather gross nature before damage is apparent.

Freezing prevents food from spoiling because at temperatures below + 15°F., the spoilage

agents cease functioning. These microorganisms, in general, do not die but they cease activity until returned to a more suitable temperature. Illness-causing organisms cease functioning at approximately + 40°F. and the psychrophilic (spoilage) organisms cease functioning at + 15°F.

Drying. Dryness furnished excellent antiseptic conditions since bacteria need moisture to grow. It increases the keeping quality of food and reduces the weight and bulk. Drying has little effect on vitamins except on Vitamin C. If dried correctly, meats may last indefinitely. Drying fruits is sometimes accomplished by exposure to sulphur fumes. This process is objected to from the standpoint of health for the reason that the sulphurous acids and sulphates are admittedly injurious. Dried milk seems to retain all its essential qualities except Vitamin C. If kept too long it will turn rancid. Dried eggs in form of egg powder keeps well and retains practically all the nutritive value of the original egg.

Salting and Pickling. The preservation of meat with brine or common salt is one of the oldest processes known. The brine should contain from 18 to 25% salt. For red meats, a little potassium nitrate or nitrite is often added because of its slight antiseptic properties and its ability to bring out the red color in the meat. The nutritive value and digestibility of salted meat is somewhat reduced. Botulism bacteria will grow better in low salt concentrations than high. Salted and pickled meats must always be watched for this possibility. The preserving action of salt depends largely upon dehydration, but also upon direct effect of the chlorine ion, removal of oxygen, and on interference with rapid action of proteolytic enzymes.

Table 18 Recommended Retail Storage Temperatures

	Degrees F.		Degrees F.		Degrees F.		Degrees F.
Fresh fruits:							
Apples	38-42	Cranberries	40-45	Grapes	40	Pears	40
Avocadoes	40-45	Currants	40-45	Grapefruit	50	Pineapples	50
Blackberries	42-45	Dates	55-60	Melons	40-45	Plums	40-45
Cantaloupe	45-55	Figs	40-45	Oranges	50	Raspberries	40-45
Cherries	40	Gooseberries	45-50	Peaches	50	Strawberries	42-45
Fresh vegetables:							
Artichokes	45	Cabbage	45	Endive	45-50	Potatoes,	
Asparagus	40	Carrots	40-45	Lettuce	45	sweet	55-60
Beans	40-45	Cauliflower	40-45	Mushrooms	55-60	Radishes	40-45
Beets	45-50	Celery	45-50	Okra	40-45	Rhubarb	45-50
Broccoli	40-45	Corn	45	Peas	40-45	Spinach	45-50
Brussels		Cucumbers	45-50	Peppers	40-45	Sauerkraut	36-38
sprouts	40-45	Eggplant	46-50	Potatoes,		Tomatoes	45-50
				white	36-40		
Meats:							
Bacon	36-40	Ham	36-40	Pork	36-40		
Beef	38-42	Lamb	36-38	Poultry	29-32		
Bologna	36-40	Lard	40-45	Sausage	36-40		
Chicken	35-40	Liver	36-38	Tongue	45-50		
Corned beef	36-40	Mutton	34-42	Veal	36-40		
Other products:		Cheese (cont'd)					
Beer	45-48	Roquefort	39-41	Cream	40-45	Lobsters,	
Bread	46-50	Skim milk	48	Dough	46-50	live	39-45
Cheese		Swiss	40	Eggs	38-45	Milk	40-45
Brick	30-35	Whole milk	34-36	Fish, fresh	25-30	Molasses	45
Cheddar	36-38	Chocolate	60-65	Honey	45-50		
Cheshire	38-40	Cider	46-50	Lobsters,			
Limburger	42-44			Boiled	36-40		
Neufchatel	50-52						

From Milk and Food Sanitation Practice -H. S. Adams

Pickling includes preservation of food in brine, vinegar, weak acids and the like. These substances have bacteriostatic and also feeble germicidal properties, depending upon their concentration. Pickled meats are prepared by soaking meat, especially pork, in a brine made of common salt, though other substances, such as sugar, vinegar and spices are often added. Sulphate of soda, boric acid, borax and benzoic acid and other chemical preservatives formerly used are no longer permitted. With proper methods, chemical antiseptics are not necessary. Trichinae die after prolonged period of pickling. Tapeworm larvae encysted in meat die usually in 21 days following death of host, but brine promptly kills these larvae.

Table 19 Storage Conditions and Properties of Perishable Products**

Product	Range of Storage Temp. ^{o} F. Over 2 weeks Warehouse	Optimum Humidity Percent Forced Air Circulation	Freezing Point ^{o} F.	Maximum Storage Period
Fruits				
*Apples	30-32	88	28.5	8 months
Apricots	31-33	85	29	12 days
*Bananas	55-56	80	26-30	10 days
Berries	31-33	85	26-29	7 to 20 days
Cantaloupe	50-55	85	30.5	20 days
Figs and dates	34-36	75	28	15 days
Grapes	30-32	85	28	1 to 6 months
*Grapefruit	32-34	90	28.5	90 days
*Lemons	50-55	85	28	90 days
*Oranges	32-34	85	28	2 months
Peaches	31-33	85	29.5	30 days
*Pears	30-32	90	28.5	1 to 7 months
Pineapples	38-40	85	28	30 days
Plums	31-33	85	28.5	15 days
Prunes	31-33	85	28.5	15 days
Strawberries	31-33	85	30	10 days
Vegetables				
Asparagus	32-34	90	30	30 days
Beans (string)	32-34	90	30	30 days
Beans (dried)	32-35	60		12 months
Beets	32-34	90	27	7 to 90 days
Broccoli	32-34	90	29	15 days
Brussel-sprouts	32-34	95	31	10 days
Cabbage	32-34	95	31	4 months
Carrots	32-34	95	29.5	2 to 4 months
Cauliflower	32-34	90	30	10 days
Celery	31-33	90	30	2 to 4 months
Corn (green)	31-33	90	29	10 days
Corn (dried)	35-40	60		12 months
Cucumbers	50-60	85	30.5	10 days
Egg Plant	50-60	90	30.5	10 days
Honey Dews	50-55	85	29	30 days
Lettuce	32-34	90	31	20 days
Onions	32-34	75	30	5 to 6 months
Parsnips	32-34	95	29	2 to 4 months
Peas (dried)	35-40	60		12 months
Potatoes	38-42	90	29	6 months
Sauerkraut	30-32	80	26	5 months
Tomatoes	50-55	85	30.5	10 days
Turnips	32-34	95	30	2 to 4 months

*These items and other fruits which give off carbon dioxide in appreciable quantities require ventilation at the rate of four to six air changes per 24 hours.

**From - Elements of Sanitation - E. S. Hopkins

Table 19 Storage Conditions and Properties of Perishable Products (Cont'd)

Product	Range of Storage Temp. ^{O} F. Over 2 weeks Warehouse	Optimum Humidity Percent Forced Air Circulation	Freezing Point ^{O} F.	Maximum Storage Period
Meats				
Bacon	28-30	85	-	15 days
Brined meats	31-32	85	-	6 months
Beef (dried)	36-40	65	-	6 months
Beef (fresh)	30-32	87	27	3 weeks
Cut meats		90	29	5 days
Fish (frozen)	5-10	80	28	6 months
Fish (iced)	30-32	85	-	15 days
Hams & loins	28-30	85	27	3 weeks
Lamb	28-30	90	29	2 weeks
Livers	20-22	80	29	6 months
Oysters (shell)	32-38	90	27	15 days
Oysters (tub)	32-38	70	27	10 days
Pork (fresh)	30-32	85	28	15 days
Pork (smoked)	28-30	85	-	15 days
Poultry (fresh	28-30	87	27	10 days
Poultry (frozen)	0-5	85	27	10 months
Sausage (casings)	31-32	80	-	4 months
Sausage (franks)	- -	90	29	48 hours
Sausage (fresh)	31-27	85	26	15 days
Sausage (smoked)	32-40	80	25	6 months
Veal	28-30	87	29	15 days
Miscellaneous				
*Beer (wood kegs)	34-38	85	28	6 months
**Beer (steel kegs)	34-38	70	28	6 months
Butter	15	80	30-0	6 months
Cavier (tub)	34-36	85	20	15 days
Cheese (American)	32-34	80	17	15 months
Cheese (Camembert)	40-45	85	18	90 days
Cheese (limburger)	31-33	85	19	60 days
Cheese (Roquefort)	40-45	80	3	60 days
Cheese (Swiss)	38-42	80	15	60 days
Chocolate (coating)	60-75	55	95-85	6 months
Cream (40%)	5-10	80	28	4 months
Eggs (frozen)	0-5	60	27	18 months
Flowers (cut)	35	90	32	1 week
Honey	31-33	70	--	12 months
Hops	32-36	65	--	May to October
Lard	32-34	80	--	6 months
Malt	48-52	80	--	May to October
Maple Sugar	31-32	70	--	May to October
Maple Syrup	31-32	70	--	May to October
Milk	35-40	70	31	5 days
Nuts (dried)	30-32	75	--	8 to 12 months
Oleo	34-36	80	--	90 days

*Wooden beer kegs weigh 66 lbs. each and have a specific heat of 0.50.
**Steel beer kegs weigh 45 lbs. each and have a specific heat of 0.10.

Preserving. Preserving is commonly understood to mean the addition of a large amount of sugar. The principle preserves are jellies, marmalades, jams and fruit butters. The cooking process which this involves usually protects against infection. Strong solutions of sugar prevent growth of bacteria, but does not kill bacteria, however, most pathogens die under such conditions in the course of time. A strong syrup (50% sugar) is necessary to prevent the growth and development of botulism toxin. Jellies are frequently adulterated by the substitution of apple stock. Apples contain a carbohydrate called pectose which aids jellification. Jellies are also colored artificially, particularly with coal-tar dyes. Artificial flavors are sometimes employed. The chemical preservatives most frequently added to jellies and preserved fruits are benzoic acid and benzoate of soda. Salicylic acid and others are prohibited.

Smoking. The smoking of fish, beef, pork, and other meat food products consists mainly in rapid drying plus the germicidal action of certain substances in the smoke like acetic acid, creosote, formaldehyde, etc. The effects of smoking only penetrate partially into the meat, therefore uncooked sausage or other raw smoked meats may be dangerous for consumption. Only hardwood or hardwood sawdust should be used for smoking products. A combination of steam and smoke is not sanctioned.

Food Chemistry Aids Progress

During the past half century the science of food chemistry had made tremendous progress. The growing, processing, and packaging of food so that it can be transported for thousands of miles and remain in good condition for months or years, is one of the wonders of modern civilization.

Additives are used for a great many interesting and useful purposes. With the aid of food chemistry the commercial cook does many things that would be difficult or impossible in the home kitchen. Our food supply has been going through an industrial revolution.

Public Health Safeguards Necessary

Food and Drug Administration scientists, appraising the situation in the mid 1950's knew that several hundred of these additives were being used. They knew also that some of those in use had not been thoroughly tested for safety. These were in a sort of scientific no-man's land — scientists did not know whether they were safe or not.

Under the Federal Food, Drug and Cosmetic Act, as it was prior to September 1958, FDA could not stop the use of a chemical simply because it was questionable or had not been adequately tested. It was necessary to be able to prove in court that the chemical was poisonous or deleterious. This is not difficult for chemicals which cause immediate, or acute, illness. But today the big problem which concerns scientists is the long-term effect — what may happen in the body as a result of years, or even a lifetime, of exposure to minute amounts of the chemical. Several years of feeding tests on different kinds of animals are required to appraise these chronic effects. Proving what is poisonous under these circumstances may be very difficult.

While most manufacturers did make tests and consult with FDA about the safety of their products, not all of them did, nor were they required to do so. Obviously, the law had to be changed so as to prevent an untested chemical from being tried out on the public. The danger was not theoretical — it was real.

A New Law for Consumer Protection

The problem of how to protect the consumer from inadequately tested food additives was studied intensively by Congressional committees from 1950 to 1958. From the first, the food and chemical industries, as well as consumers, supported the principle that safety testing should be required by law. The Food Additives Amendment, Public Law 85-929, became law September 6, 1958. It became fully effective for all new chemicals on March 9, 1959. An additional year was allowed to complete tests of chemicals in use prior to January 1, 1958, in the absence of any reason to believe the chemical unsafe. Food additives include all substances not exempted by law, the intended use of which results or may reasonably be expected to result directly or indirectly, either in their becoming a component of food or otherwise affecting the characteristics of food. The term "food additive" (as defined in the 1962 amendment) means any substance the intended use of which results or may reasonably be expected to result, directly or indirectly, in its becoming a component or otherwise affecting the characteristics of any food (including any substance intended for use in producing, manufacturing, packing, processing, preparing, treating, packaging, transporting, or holding food; and including any source of radiation intended for any such use), if such substance be not generally recognized, among experts qualified by scientific training and experience to evaluate its safety, as having been adequately shown through scientific procedures (or, in the case of a substance used in food prior to January 1, 1958, through either scientific procedures or experience based on common use in food) to be safe under the conditions of its intended use; except that such term does not include:

1. a pesticide chemical in or on a raw agricultural commodity; or
2. a pesticide chemical to the extent that it is intended for use or is used in the produc-

tion, storage, or transportation of any raw agricultural commodity; or

3. a color additive; or

4. any substance used in accordance with a sanction or approval granted prior to the enactment of this paragraph pursuant to this Act, the Poultry Products Inspection Act, or the Meat Inspection Act of March 4, 1907 as amended and extended.

The term "new drug" means: Any drug the composition of which is such that such drug is not generally recognized among experts qualified by scientific training and experience to evaluate the safety and effectiveness of drugs, as safe and effective for use under the conditions prescribed, recommended, or suggested in the labeling thereof, except that such drug not so recognized shall not be deemed to be a "new drug" if at any time prior to the enactment of this Act it was subject to the Food and Drugs Act of June 30, 1906, as amended, and if at such time its labeling contained the same representations concerning the conditions of its use; or any drug the composition of which is such that such drug, as a result of investigations to determine its safety and effectiveness for use under such conditions, has become so recognized, but which has not, otherwise than in such investigations, been used to a material extent or for a material time under such conditions.

The term "pesticide chemical" means any substance which, alone, in chemical combination or in formulation with one or more other substances, is an "economic poison" within the meaning of the Federal Insecticide, Fungicide, and Rodenticide Act as now in force or as hereafter amended, and which is used in the production, storage, or transportation or raw agricultural commodities.

The term "raw agricultural commodity" means any food in its raw or natural state, including all fruits that are washed, colored, or otherwise treated in their unpeeled natural form prior to marketing.

Butter. The Act of March 4, 1923, defines butter as "For the purposes of this chapter 'butter' shall be understood to mean the food product usually known as butter, and which is made exclusively from milk or cream, or both, with or without common salt, and with or without additional coloring matter, and containing not less than 80 per centum by weight of milk fat, all tolerances having been allowed for."

Nonfat Dry Milk. The Act of July 2, 1956, defines nonfat dry milk as follows:" ..... for the purpose of the Federal Food, Drug, and Cosmetic Act of June 26, 1938, nonfat dry milk is the product resulting from the removal of fat and water from milk, and contains the lactose, milk proteins, and milk minerals in the same relative proportions as in the fresh milk from which made. It contains not over 5 per centum by weight of moisture. The fat content is not over 1-1/2 per centum by weight unless otherwise indicated.

"The term 'milk', when used herein, means sweet milk of cows."

Food Additives

Food and chemical manufacturers are now required to run extensive animal feeding tests on the additives before they are marketed. Results of these tests must be submitted to the Food and Drug Administration. If FDA be satisfied that the additive will be safe, a regulation will be issued permitting its use. This regulation will place a limit, or "tolerance," on the amount which may be used, and will specify any other conditions necessary to protect the public health. If the evidence submitted be not convincing as to safety, the additive will not be permitted. This applies equally to substances added directly to foods and to substances likely to contaminate food by migrating into it as a result of some incidental use in food processing. The latter type of additives is called migrants, examples of which are copper, cadmium, lead, and the like which may adulterate food from containers, fittings, seals, pins and similar devices resulting from contact. Food packing materials which may migrate into the food itself are covered

in the law. The law also applies specifically to processes for irradiating foods for preservation or other technical effect, and it covers any residues which may carry over into meat, milk, or eggs as a result of use in animal feeds.

The law specifically states that no additive may be permitted in any amount if the tests show that it produces cancer when fed to man or animals, or by other appropriate test. And it specifies that only the smallest amount necessary to produce the intended effect may be permitted. It prohibits the use of any chemical which would result in consumer deception.

Important Classes of Food Additives: Some of the additives in the several classes may belong to more than one class. Such common ones as salt, pepper, sugar, and vinegar are not listed.

Nutrient Supplements: These are the vitamins and minerals added to foods to improve nutritive value, and sometimes to replace those removed in processing. Those generally recognized as safe and exempt from tolerance levels are:

Ascorbic acid.
Calcium carbonate.
Calcium oxide.
Calcium pantothenate.
Calcium phosphate (mono-, di-, tribasic).
Calcium sulfate.
Carotene.
Ferric phosphate.
Ferric pyrophosphate.
Ferric sodium pyrophosphate.
Ferrous sulfate.
Iron, reduced.
l-Lysine monohydrochloride.
Niacin.
Niacinamide.
D-Pantothenyl alcohol.
Potassium chloride.
Pyridoxine hydrochloride.
Riboflavin.
Riboflavin-5-phosphate.
Sodium pantothenate.
Sodium phosphate (mono-, di-, tribasic).
Thiamine hydrochloride.
Thiamine mononitrate.
Tocopherols.
α-Tocopherol acetate.
Vitamin A.
Vitamin A acetate.
Vitamin A palmitate.
Vitamin B_{12}.
Vitamin D_2.
Vitamin D_3.

Nonnutritive Sweeteners. These are the sugar substitutes exempt from tolerances and permitted in foods for people who must restrict their intake of ordinary sweets. They are: Calcium cyclohexyl sulfamate, calcium saccharin, saccharin, sodium cyclohexyl sulfamate, sodium saccharin.

Chemical Preservatives. Chemical preservatives are mostly of bacteriostatic nature in the proportions commonly used, but may have some germicidal action. Upon general principles, we need be circumspect in adding chemical substance of whatever nature to food for the purpose of preserving, coloring or improving its appearance, since by such a method dangerous foods are often disguised. Benzoic acid and benzoate of soda are weak germicides at best. The reason why benzoic acid in moderate amounts is believed to be harmless is that the body possesses a special mechanism for taking care of this substance. The Federal authorities permit the use of benzoate of soda in quantities not exceeding 0. 1% in certain foods, but the addition must be plainly labelled. Borax and boric acid are antiseptics. They are usually used together since in combination they are more efficient. These substances are not allowed as direct additives in food in the United States. Their effect on the body is not entirely clear, and since there are better methods of preserving foods, they are forbidden. Formaldehyde is injurious to the body and is forbidden in practically all countries as a direct additive for foods. Salicylic acid is a poison to the body and its use is prohibited by the Federal food regulations. Potassium permanganate should not be used on the surface of meat to destroy the surface evidence of decomposition. Hydrofluoric acid is a good disinfectant but should not be used in food. Sodium fluoride has strong antiseptic properties but is a powerful poison. Sodium sulphite, sodium bisulphate, and sulphurous acid are used principally upon fresh meats where they act as preservatives and as retainers of color. These chemicals are irritating and dangerous to the body and are forbidden from use in food. Sodium nitrate and nitrite and potassium nitrate and nitrite are not used as preservatives but usually for retaining or accentuating the red color in meat. These are not known to be harmful in small quantities, and are allowed for use in curing meat so long as the finished food product contains no more than 200 ppm. In large doses nitrates (which are reduced to nitrites in the food) can be harmful by reducing the hemoglobin of the blood to methemoglobin. Sulphur dioxide is employed for bleaching fruits and is allowed if labeled correctly, but when it is used in abnormal quantities for disguising excessive moisture contents of foods it is forbidden. Sodium bicarbonate is sometimes added to milk in order to neutralize the excess acid and delay souring but this should be discouraged. It is too ineffective as a germicide for general use as a food perservative. Hydrogen peroxide is perhaps one of the least dangerous of the chemical preservatives, and if used in milk will destroy vitamin C.

Its use should be prohibited. The use of preservatives containing lead, arsenic or other substances known to be poisonous is strictly forbidden. Spices such as ginger and black pepper fail to prevent growth of bacteria. Nutmeg and allspice have slight and temporary bacteriostatic properties. Cinnamon, cloves and mustard on the other hand have marked antiseptic powers.

Glycerine may not be added to food. Since ozone affects the sense of smell and also masks odors thereby interfering with inspections, the use of ozone as a preservative is prohibited except in coolers set aside for the so-called quick-aging of beef. Lye solution for removing the outer surface of vegetables has been permitted provided the lye be completely removed before the vegetables are processed.

Since the mass production of antibiotics has resulted in the relative cheapness of the cost of such preservatives, the problem of their use as bactericidal and bacteriostatic agents in food is coming to the fore. They are hazardous from the point of view of causing mass allergy in the population, and in causing the development of strains of bacteria which are resistant to antibiotics.

Acronize is the trade-mark for the various formulated products of the special food-grade chlortetracycline with salt and citric acid.

The normal store life of a chicken carcass under standard commercial refrigeration is approximately 7 days. Chlortetracycline will extend this period to between 14 and 21 days.

The preservative is used in the chilling tanks into which the poultry is routinely placed at the end of the eviscerating procedure. The carcasses remain in these tanks for about 2 hours to remove the body heat and slow down bacterial growth. The final concentration of the active chlortetracycline in the ice-slush mixture approximates 10 ppm., as recommended by the manufacturers. The highest concentration in the poultry meat is usually in the outer breast muscle where it may approximate 2 ppm. but usually lower.

Chlortetracycline will be inactivated during the cooking of poultry. It has been found that this antibiotic will extend the keeping time of round fish, stored in acronized ice, by about 50%, and for drawn fish by about 70%. Shell fish showed as much as 100% increase in keeping time.

There are many different types of preservatives, each type being best suited to a particular type of product, or more effective against a particular spoilage organism or chemical change. Preservatives for fatty products, for example, are called antioxidants, such as propyl gallate. The preservatives used in bread are called mold and rope inhibitors, or antimycotic agents. Other antimycotics prevent molding of citrus fruits and are called fungicides because they stop the growth of the mold or fungus spores. Chemical preservatives which are exempt from tolerance levels are: Ascorbic acid, ascorbyl palmitate, calcium propionate, erythorbic acid, potassium sorbate, propionic acid, sodium ascorbate, sodium propionate, sodium sorbate, sorbic acid, tocopherols, calcium ascorbate.

The type of preservative which prevents physical or chemical changes that affect color, flavor, texture or appearance are called sequestrants. Another type of sequestrant is used in the manufacture of soft drinks to remove traces of metals which cause clouding or other undesirable affect. Those sequestrants not requiring tolerance levels are (for the purpose of this list, no attempt has been made to designate those sequestrants which may also function as chemical preservatives):

Calcium acetate.
Calcium chloride.
Calcium citrate.
Calcium diacetate.
Calcium gluconate.
Calcium hexametaphosphate.
Calcium phytate.
Citric acid.
Dipotassium phosphate.
Disodium phosphate.
Monocalcium acid phosphate.
Monoisopropyl citrate.
Potassium citrate.
Sodium acid phosphate.
Sodium citrate.
Sodium diacetate.
Sodium gluconate.
Sodium hexametaphosphate.
Sodium metaphosphate.
Sodium phosphate (mono-, di-, tribasic-).
Sodium potassium tartrate.
Sodium pyrophosphate.
Sodium tartrate.
Sodium tetrapyrophosphate.
Sodium tripolyphosphate.
Tartaric acid.

Emulsifiers. Emulsifiers such as lecithin are used in such foods as bakery products, cake mixes, ice cream and frozen desserts, and confectionery products. They affect characteristics such as volume, uniformity, fineness of grain (bakery goods), ease of emulsification and smoothness (dairy products), and homogeneity and keeping quality (confectionery). Chemists sometimes call the emulsifiers, surfactants — short for "surface active agents." Those not requiring tolerance levels are: Diacetyl tartaric acid esters of mono- and diglycerides from the glycerolysis of edible fats or oils, mono- and diglycerides from the glycerolysis of edible fats or oils, monosodium phosphate derivatives of mono- and diglycerides from the glycerolysis of edible fats or oils, propylene glycol.

Stabilizers and Thickeners. Smoothness and texture of confectionery, ice cream and other frozen desserts; uniformity of color, flavor and viscosity of chocolate milk; "body" of artifically sweetened beverages, homogenization of certain fruit juices: these are typical of the purposes for which stabilizers and thickeners such as pectins and gelatin are used. Others not requiring tolerance levels are: Vegetable gums (carob bean, carragheen, guar), and agar agar.

Acids, Alkalies, Buffers, Neutralizing Agents. The degree of acidity or alkalinity is important in many classes of processed foods. The acid ingredient acts on the leavening agent in baked goods, and releases the gas which causes rising. The taste of many soft drinks is due largely to an organic acid. Acidity of churning cream must be controlled for flavor and keeping quality of the butter. Acids contribute flavor to confectionery, and help to prevent a "grainy" texture. Buffers and neutralizing agents are chemicals added to control acidity or alkalinity, just as acids and alkalies may be added directly. Those not requiring tolerance levels are:

Acetic acid.
Aluminum ammonium sulfate.
Aluminum sodium sulfate.
Aluminum potassium sulfate.
Ammonium bicarbonate.
Ammonium carbonate.
Ammonium hydroxide.
Ammonium phosphate (mono- and dibasic-).
Calcium carbonate.
Calcium chloride.
Calcium citrate.
Calcium gluconate.
Calcium hydroxide.
Calcium lactate.
Calcium oxide.
Calcium phosphate.
Citric acid.
Lactic acid.
Magnesium carbonate.
Magnesium oxide.
Potassium acid tartrate.
Potassium bicarbonate.
Potassium carbonate.
Potassium citrate
Potassium hydroxide.
Sodium acetate.
Sodium acid pyrophosphate.
Sodium aluminum phosphate.
Sodium bicarbonate.
Sodium carbonate.
Sodium citrate.
Sodium hydroxide.
Sodium phosphate (mono-, di-, tri-).
Sodium potassium tartrate.
Sodium sesquicarbonate.
Sulfuric acid.
Tartaric acid.

Flavoring Agents. Typical of the synthetic flavors used in such products as soft drinks, bakery goods, confectionery and ice cream are such chemicals as amyl acetate, benzaldehyde, carvone, ethyl butyrate and methyl salicylate. Essential oils, such as oil of orange and oil of lemon, are natural flavors made by extraction of the fruit rind or other natural product. Monosodium glutamate is a seasoning agent made from plant protein. Many food additives are derived from foods or are identical with substances naturally occurring in foods.

Bleaching Agents: Bread Improvers. Freshly milled flour is yellowish in color and makes a very poor dough. As it ages, it whitens and reacts chemically with oxygen in the air, and gradually improves in breadmaking quality. This aging and bleaching can be speeded up to avoid long periods of storage by the adding of oxidizing chemicals. Some of the permissible oxidizing and bleaching agents are benzoyl peroxide, oxides of nitrogen, chlorine dioxide, nitrosyl chloride, chlorine, and potassium bromate. Some of the chemicals added as yeast foods and dough conditioners are ammonium chloride, calcium sulfate, ammonium phosphates, and calcium phosphates.

There are of course other classes of additives for other purposes than those named. Leavening agents, anticaking agents, hardening agents, clarifying and chillproofing agents, propellants (for products packed under pressure in dispensing cans), drying agents, and antifoaming agents, are examples.

A group of miscellaneous additives not requiring tolerance levels are:

Acetic acid.
Aluminum sodium sulfate.
Aluminum sulfate.
Butane.
Calcium phosphate, tribasic.
Caramel.
Carbon dioxide.
Carnauba wax.
Citric acid.
Glycerin.
Glycerol monostearate.
Helium.
Magnesium carbonate.
Magnesium hydroxide.
Monoammonium glutamate.
Nitrogen.
Papain.
Phosphoric acid.
Propane.
Propylene glycol.
Triacetin (glyceryl triacetate).
Tricalcium phosphate.
Sodium carbonate.
Sodium phosphate.
Sodium tripolyphosphate.

Food Additives requiring specific tolerances, uses, or restrictions are given in the following table:

Certain Food Additives Not Exempt From the Requirement of Tolerances

Product	Tolerance	Specific uses or restrictions
ANTICAKING AGENTS		
Aluminum calcium silicate	2 percent	In table salt.
Calcium silicate	5 percent	In baking powder.
Calcium silicate	2 percent	In table salt.
Magnesium silicate	do	Do.
Tricalcium silicate	do	Do.
CHEMICAL PRESERVATIVES		
Benzoic acid	0.1 percent	
Butylated hydroxyanisole	Total content of antioxidants not over 0.02 percent of fat or oil content, including essential (volatile) oil content, of food.	
Butylated hydroxytoluene	do	
Caprylic acid		In cheese wraps.
Dilauryl thiodipropionate	Total content of antioxidants not over 0.02 percent of fat or oil content, including essential (volatile) oil content of the food.	
Gum guaiac	0.1 percent (equivalent antioxidant activity 0.01 percent).	In edible fats or oils.
Nordihydroguaiaretic acid	Total content of antioxidants not over 0.02 percent of fat or oil content, including essential (volatile) oil content of the food.	
Potassium bisulfite		Not in meats or in food recognizable as a source of vitamin B_1.
Potassium metabisulfite		Do.
Propyl gallate	Total content of antioxidants not over 0.02 percent of fat or oil content, including essential (volatile) oil content of the food.	
Sodium benzoate	0.1 percent	
CHEMICAL PRESERVATIVES—con.		
Sodium bisulfite		Not in meats or in foods recognizable as a source of vitamin B_1.
Sodium metabisulfite		Do.
Sodium sulfite		Do.
Sulfur dioxide		Do.
Thiodipropionic acid	Total content of antioxidants not over 0.02 percent of fat or oil content, including essential (volatile) oil content of the food.	
EMULSIFYING AGENTS		
Cholic acid	0.1 percent	Dried egg whites.
Dexoxycholic acid	do	Do.
Glycocholic acid	do	Do.
Ox bile extract	do	Do.
Taurocholic acid (or its sodium salt)	do	Do.
MISCELLANEOUS		
Caffeine	0.02 percent	In cola type beverages.
Ethyl formate	0.0015 percent	As fumigant for cashew nuts.
Magnesium stearate		As migratory substance from packaging materials when used as a stabilizer.
Sorbitol	7.0 percent	In foods for special dietary use.
Triethyl citrate	0.25 percent	Egg whites.
NUTRIENTS		
Copper gluconate	0.005 percent	
Cuprous iodide	0.01 percent	In table salt as a source of dietary iodine.
Potassium iodide	do	Do.
SEQUESTRANTS [1]		
Isopropyl citrate	0.02 percent	
Sodium thiosulfate	0.1 percent	In salt.
Stearyl citrate	0.15 percent	

[1] For the purpose of this list no attempt has been made to designate those sequestrants which may also function as chemical preservatives.

Newer food additives requiring specific tolerances, uses, and restrictions are:

Chlortetracycline in chicken feed. Quantities permitted are between 110 ppm. and 220 ppm. in finished product. Tolerance for chlortetracycline in uncooked kidney of chicken is 4 ppm; in uncooked chicken muscle, liver, fat and skin is 1 ppm; in or on fresh, uncooked, unfrozen fish (vertebrate), scallops (shucked), shrimp (unpeeled) is 5 ppm.

1, 2-Dihydro-6-ethoxy-2, 2, 4-trime thylquinoline - in poultry feed or in dehydrated forage crop. The final mixed poultry feed, or dehydrated forage crop must not have more than 150 ppm. of this additive. Tolerances for this chemical in meat from animals slaughtered for human food are: 0.5 ppm. for uncooked meat or meat products, eggs, and poultry; and 3.0 ppm. for uncooked poultry livers and fat.

2, 3, -p-Dioxanedithiol - S-S-bis (0, 0 diethyl phosphorodithionate). Tolerance level of 18 ppm. for residues in dehydrated citrus pulp for cattle feed.

Gibberellic acid and its potassium salt - together not to exceed 2 ppm. in malt (expressed as gibberellic acid); not to exceed 0.5 ppm. in finished malt beverages; and zero for finished distilled spirits.

Glyceryl lactostearate and mono-and diglycerides may be used as emulsifiers or with shortening when their content has 4.7 to 13.0% lactic acid, 5 to 25% monostearin, saponification number between 190 and 250, and an acid number between 2 and 14.

Maleic hydrazide in potato chips - not to exceed 160 ppm. by weight in finished product.

Manganese bacitracin in chicken and swine feed. Not more than 10 grams per ton of final manufactured feed is allowed.

Oleandomycin in chicken and turkey feed. Quantity of additive permitted is an equivalence of 1.1 ppm. to 2.2 ppm. oleandomycin activity per ton of feed.

Reserpine in chicken and turkey feed. Quantities of additive permitted in or on feed are: 2 ppm. for laying hens, 1 ppm. for broilers and turkeys, 0.2 ppm. prophylactic use for turkeys.

Zoalene (3, 5-dinitro-o-toluamide) in chicken feed. Quantity permitted is 125 ppm. in the finished medicated feed. Tolerance for zoalene and its metabolite (3-amino-5-nitro-o-toluamide) in uncooked chicken muscle and fat is 2 ppm., and in uncooked chicken liver and kidney is 6 ppm.

A tolerance of zero is established for the following additives in human food or milk: Benzathene penicillin V, procaine penicillin, neomycin, polymixin, hydrocortisone acetate, hydrocortisone sodium succinate, manganese bacitracin, reserpine, oleandomycin.

Safety of Surfactants in Foods: More than 2600 synthetic detergents and emulsifiers were in use in the United States in 1955. These, along with naturally occurring surface-active agents, are commonly referred to as surfactants. Materials that raise surface tension might also be called surfactants, but they are relatively unimportant in food processing and are not considered here. A small number of surfactants are added intentionally to foods for their emulsifying properties in amounts ranging from less than 0.1 per cent to more than 6.0 per cent. A large number are increasingly important as detergents, penetrants, emulsifiers, wetting agents, and sanitizing agents in food processing establishments and in the production of food packaging materials. As a result of such use, these surfactants may occur incidentally in some foods in amounts of a few parts per million.

Surfactants comprise a diverse group of chemical compounds. One common property of these compounds is their ability to reduce interfacial tension*, a consequence of their molecular structure. Many biological materials exhibit this property, for example bile salts, phospholipids, mono- and diglycerides, proteins, and soaps. Some naturally occurring surfactants are essential in the digestion of fats and in their absorption.

Surfactants may be classified into three groups according to their ionization in water:

Cationics - which yield positively charged organic ions in water. Examples are the quaternary ammonium compounds.

Anionics - which yield negatively charged organic ions in water. Examples are soaps, bile salts, alkyl and aryl sulfates, and sulfonates.

Nonionics - which are not ionized in water. Examples are mono- and diglycerides of fatty acids and polyoxyethylene stearate.

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* Interfacial tension is surface tension at the boundary (interface) of two liquids. What reduces or raises surface tension of one of the liquids also reduces or raises the surface tension at the interface.

Because the structure and activities of living cells and the functioning of many enzyme systems are dependent upon specific interfacial tensions, it is proper to inquire whether the addition to food of any material possessing the ability to lower interfacial tension is safe. If the reduction of interfacial tension per se be harmful, and if such reduction be brought about by surfactants entering the digestive tract regardless of the chemical constitution of the agent, then no surfactant in amounts which lower surface tension after consumption could be safely present in food. The Food Protection Committee of the Food and Nutrition Board concludes* that there are no toxic effects common to all surfactants. Surface activity per se is not a measure of toxicity. The safety of each surfactant for use in food must be determined separately.

Pesticides. The food additive amendment does not cover pesticides used on growing crops, or coal-tar colors used in or on foods, because these substances were already dealt with by other special provisions of the law. The Miller Amendment of 1954 established a procedure for the setting of safe limits or "tolerances" for residues of pesticides which may remain on fresh fruits and vegetables when shipped. FDA sets these tolerances based upon results of animal tests which the pesticide manufacturer is required to submit. There must also be ample evidence that these tolerance amounts will not be exceeded when the product is used according to the directions on its label. The pesticide label must be registered with the U.S. Department of Agriculture, and that Department must certify to the Food and Drug Administration that the product will be useful in agriculture.

A compact instrument for detecting pesticide in food has been developed. A fraction of an ounce of suspected food is chopped up, dissolved and injected into the analyzer. Any contamination with pesticide is detected and recorded on a chart. The technique is called gas chromatography, but the new "pestilyzer" has a special detector that is specifically sensitive to pesticide compounds. The instrument can analyze any pesticide, even if it be present only in the parts per billion range. The pestilyzer provides the chemist with a powerful tool for analysis and control of pesticide residues in foods such as milk, beef, fruit, flour, etc.

See Addendum II on Food Additives.

Canning. The process of canning is practically synonymous with sterilization, and is, therefore, one of the best sanitary safeguards we have against parasites and bacterial injury in foodstuffs. The process of canning was discovered in Paris in 1804 to 1810 long before the days of bacteriology. The time and temperature for processing each article depend on various factors such as size of the pressure cooker, the food in the can, and the size of the can. Only fresh and sound fruits and vegetables should be put up. There is a fable extant, that once a can is opened and not emptied, the food in the can acquires injurious properties. The only time that such food becomes injurious is when it becomes contaminated and is not adequately refrigerated. The process of canning fortunately does not interfere seriously with most vitamins.

The keeping qualities of canned foods vary with the product. In many instances they may be kept two or three years without appreciable change. All canned products keep better cold.

Spoilage of canned foods which may be observed by examining the can are usually classified as:

1) Leaks. These are due to improper sealing, brittle metal, and erosion. Large leaks allow the loss of part of the contents and cause stains on the can. Small leaks allow only the loss of the vacuum but not of the contents. In such a case, on tapping the can with a piece of wood or tapping instrument, a hallow sound is elicited instead of a dull sound. Overstuffed cans or cans containing much liquid may yield a dull note even though no vacuum be present. In some instances, a leaking can may be detected by compression under water which will force air bubbles from the can if a relatively large aperture be present. A suspected leaker may be slowly heated to about 100 degrees F. and then allowed to cool. If a leak be present, the concavity of the ends or sides will disappear. A leaker may become a sweller or a springer.

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* The Relation of Surface Activity to Safety of Surfactants in Food, Publication 463, National Academy of Sciences, National Research Council, 1956.

2) Swells. These are caused by the production of gas by microorganisms from lack of sterilization of the contents or by infection through leaks. The name is derived from the distention or puffing of the ends of the can from internal gas pressure. The gas is usually carbon-dioxide although other malodorous gases may be mixed with it. The product is often offensive, sour, and discolored. Occasionally, chemical changes may cause the formation of gas, or air may leak into the can. In the latter case the can is a leaker as well as a sweller. A sweller can be detected by appearance of the can. When gas present is insufficient to cause bulging, it may be detected by tapping the can and eliciting a hallow note.

The term "puffer" has the same significance as "swell" but is usually used to refer to canned meat swells.

3) Springer or flipper is the condition of the can where one end is distended, or upon manipulation the distention may pass from one end to the opposite. A springer differs from a sweller only in that the accumulation of gas within the can is not sufficient to eliminate entirely the negative pressure, but there is enough gas to eliminate the concavity from one end of the can. In some cases both ends may show distention during hot weather or high altitude and return to normal in a cool place or lower level. This condition is not due to spoilage by microorganisms, but to overfilling, insufficient vacuum, microscopic leaks, or to the action of the food upon the container.

Spoilage of canned foods which can be observed only by examining the contents of the can are usually classified as:

1) Flat sours. This results from undercooking or lack of cooling. The organisms responsible grow without gas formation and may be of the thermoduric or thermophilic types. The contents contain an abnormal amount of acidity. This condition occurs more often on inside stacks of cans than in the outer rows.

2) Stack Burning. This results from storing cans while too warm thus holding heat for several days. The contents soften and even become soupy, darken in color, and acquire a disagreeable flavor. The cans look galvanized or become a dull leaden color on the inside. This occurs most often in canned tomatoes.

The freezing of canned goods may cause the contents to become flabby and appear water-logged.

The discoloration of the contents of cans may be due to the effect of various metals upon the food substance, to the effect of high or prolonged heating, or to bacterial action.

Foreign flavors of canned foods are most often acquired before being placed in the cans. Fermentation will produce a sour taste. Fruits such as peaches and apricots acquire a piney flavor from standing too long in pine lug boxes. Fruits may develop a musty taste in cold storage. Phenol flavors are quickly acquired if substances with carbolic acid are allowed to stand near the fruits. Lacquered cans may sometimes produce objectionable flavors.

When a can is opened for inspection, care must be taken to avoid damage of its contents. The contents should be carefully examined for abnormal odor, appearance, or taste indicative of decomposition. The inside surface of the can and adjacent food should be inspected for presence of black discoloration due to chemical reaction between contents and metal. Laboratory examination of contents should be made to determine presence of adulteration, preservatives, or bacterial decomposition.

The factors responsible for unsatisfactory results in canning foods can be summarized as follows:

(1) Use of unfit raw material.
(2) Use of unfit cans and glass jars.
(3) Carelessness in the technic of cleanliness.
(4) Overfilling the cans.
(5) Carelessness in sealing the cans.
(6) Imperfect degrees of processing.
(7) Unsatisfactory methods of storage.

Practically all foods canned in the ordinary way contain some tin. Canned lobster and shrimp are relatively active as solvents of tin and therefore are packed in lacquered or enameled cans. Fortunately tin is not very toxic. The tin coating on cans is not always perfect and may be injured by manipulation, thus exposing the iron. Glass containers have advantages but are more expensive.

Food Service Sanitation: Foods may be safely produced, preserved and stored, but may still become unsafe in the process of careless and unsanitary preparation, and distribution for serving to the consumer. Uniform regulations for this area of sanitation which could be adopted nation-wide were first developed by the U.S. Public Health Service in 1934 and published as a tentative draft in 1935. After sufficient field trials these were revised and published in 1940 under the title: Ordinance and Code Regulating Eating and Drinking establishments - Recommended by the U.S. Public Health Service. This was again revised in 1943.

During the past two decades, however, advances in food technology, together with a distinct change in the social pattern of living in this country, have perceptibly altered the eating habits of our people, and concurrently therewith, the types of food service operations being employed in public food-service establishments. In recognition of these changes, the Public Health Service developed a new food service manual in 1962 as a guide for both public health agencies and the food-service industry. The manual sets forth the need, purpose, and scope of a food protection program, and suggests ways and means whereby effective programs may be implemented. It also includes a recommended ordinance and code to replace the 1943 edition. While the ordinance and code has been designed specifically for the public health protection of food served in food-service establishments, its technical provisions are equally applicable to the protection of potentially hazardous food wherever it is prepared, served, or displayed. Provision is made for two alternate forms of enforcement, i.e., by permit revocation, and by downgrading or permit revocation, or both.

The complete ordinance and selected essential parts of the code are presented below. The ordinance sections are followed by annotations under two headings, public health reason, and satisfactory compliance. Because most public health reasons for each item are easily apparent to the sanitarian or can be found in other parts of this book, only some of these annotations are here included.

United States Public Health Service Food Service Sanitation Ordinance and Code, 1962

An ordinance defining food, potentially hazardous food, adulterated, misbranded, food-service establishment, temporary food-service establishment, health authority, utensils, equipment, etc.; providing for the sale of only unadulterated, wholesome, properly branded food; regulating the sources of food; establishing sanitation standards for food, food protection, food-service personnel, food-service operations, food equipment and utensils, sanitary facilities and controls, and other facilities; requiring permits for the operation of food-service establishments; regulating the inspection (grading, regarding, and placarding)[1] of such establishments; providing for the examination and condemnation of food; and providing for the enforcement of this ordinance, and the fixing of penalties.

Be it ordained by the _____ of the municipality[2] of _____ as follows:

Section A. Definitions

The following definitions shall apply in the interpretation and the enforcement of this ordinance:

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1. Communities which wish to adopt the nongrading form of the ordinance should delete this parenthetical expression. Communities wishing to use the grading form of the ordinance should delete only the parentheses.
2. Substitute proper legal jurisdiction here and in all similar places throughout the ordinance.

1. ADULTERATED shall mean the condition of a food (a) if it bears or contains any poisonous or deleterious substance in a quantity which may render it injurious to health; (b) if it bears or contains any added poisonous or deleterious substance for which no safe tolerance has been established by regulation, or in excess of such tolerance if one has been established; (c) if it consists in whole or in part of any filthy, putrid, or decomposed substance, or if it be otherwise unfit for human consumption; (d) if it has been processed, prepared, packed, or held under insanitary conditions, whereby it may have become contaminated with filth, or whereby it may have been rendered injurious to health; (e) if it be in whole or in part the product of a diseased animal, or an animal which has died otherwise than by slaughter; or (f) if its container be composed in whole or in part of any poisonous or deleterious substance which may render the contents injurious to health.

2. APPROVED shall mean acceptable to the health authority based on his determination as to conformance with appropriate standards and good public health practice.

3. CLOSED shall mean fitted together snugly leaving no openings large enough to permit the entrance of vermin.

4. CORROSION RESISTANT MATERIAL shall mean a material which maintains its original surface characteristics under prolonged influence of the food, cleaning compounds, and sanitizing solutions which may contact it.

5. EASILY CLEANABLE shall mean readily accessible and of such material and finish, and so fabricated that residue may be completely removed by normal cleaning methods.

6. EMPLOYEE shall mean any person working in a food-service establishment who transports food or food containers, who engages in food preparation or service, or who comes in contact with any food utensils or equipment.

7. EQUIPMENT shall mean all stoves, ranges, hoods, meatblocks, tables, counters, refrigerator, sinks, dishwashing machines, steamtables, and similar items, other than utensils, used in the operation of a food-service establishment.

8. FOOD shall mean any raw, cooked, or processed edible substances, beverage or ingredient used or intended for use or for sale in whole or in part for human consumption.

9. FOOD-CONTACT SURFACES shall mean those surfaces of equipment and utensils with which food normally comes in contact, and those surfaces with which food may come in contact and drain back onto surfaces normally in contact with food.

10. FOOD-PROCESSING ESTABLISHMENT shall mean a commercial establishment in which food is processed or otherwise prepared and packaged for human consumption.

11. FOOD SERVICE ESTABLISHMENT shall mean any fixed or mobile restaurant; coffee shop; cafeteria; short-order cafe; luncheonette; grill; tearoom; sandwich shop; soda fountain; tavern; bar; cocktail lounge; night club; roadside stand; industrial feeding establishment; private, public, or nonprofit organization or institution routinely serving food; catering kitchen; commissary or similar place in which food or drink is prepared for sale or for service on the premises or elsewhere; and any other eating or drinking establishment or operation where food is served or provided for the public with or without charge.

12. HEALTH AUTHORITY[3] shall mean the health authority of the municipality[4] of _____ or his designated representative.

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3. In jurisdictions where the authority for the enforcement of this ordinance is vested in any agency other than the health department, the proper authority should be substituted for the term "health authority" wherever the term appears in this ordinance.
4. See footnote 2.

13. KITCHENWARE shall mean all multiuse utensils other than tableware used in the storage, preparation, conveying, or serving of food.

14. MISBRANDED shall mean the presence of any written, printed, or graphic matter, upon or accompanying food or containers of food, which is false or misleading, or which violates any applicable State or local labelling requirements.

15. PERISHABLE FOOD shall mean any food of such type or in such condition as may spoil.

16. PERSON shall mean an individual, or a firm, partnership, company, corporation, trustee, association, or any public or private entity.

17. POTENTIALLY HAZARDOUS FOOD shall mean any perishable food which consists in whole or in part of milk or milk products, eggs, meat, poultry, fish, shellfish, or other ingredients capable of supporting rapid and progressive growth of infectious or toxigenic micro-organisms.

18. SAFE TEMPERATURES, as applied to potentially hazardous food, shall mean temperatures of 45°F. or below, and 140°F. or above.

19. SANITIZE shall mean effective bactericidal treatment of clean surfaces of equipment and utensils by a process which has been approved by the health authority as being effective in destroying micro-organisms, including pathogens.

20. SEALED shall mean free of cracks or other openings which permit the entry or passage of moisture.

21. SINGLE-SERVICE ARTICLES shall mean cups, containers, lids or closures; plates, knives, forks, spoons, stirrers, paddles; straws, place mats, napkins, doilies, wrapping materials; and all similar articles which are constructed wholly or in part from paper, paperboard, molded pulp, foil, wood, plastic, synthetic, or other readily destructible materials, and which are intended by the manufacturers and generally recognized by the public as for one usage only, then to be discarded.

22. TABLEWARE shall mean all multiuse eating and drinking utensils, including flatware (knives, forks, and spoons).

23. TEMPORARY FOOD-SERVICE ESTABLISHMENT shall mean any food-service establishment which operates at a fixed location for a temporary period of time, not to exceed 2 weeks, in connection with a fair, carnival, circus, public exhibition, or similar transitory gathering.

24. UTENSIL shall mean any tableware and kitchenware used in the storage, preparation, conveying, or serving of food.

25. WHOLESOME shall mean in sound condition, clean, free from adulteration, and otherwise suitable for use as human food.

Section B. Food

1. Food Supplies: All food in food-service establishments shall be from sources approved or considered satisfactory by the health authority, and shall be clean, wholesome, free from spoilage, free from adulteration and misbranding, and safe for human consumption. No hermetically sealed, nonacid, and low-acid food which has been processed in a place other than a commercial food-processing establishment shall be used.

Reason: The use of noncommercially processed, hermetically sealed, nonacid, and low-acid food--i.e., food with a pH of more than 4.5--is prohibited because of the history of such food in causing botulism, a type of food poisoning which is frequently fatal. For this reason,

such food is required to be obtained only from sources where the conditions and methods of preparation are subject to official regulation or surveillance by State or local governmental authorities.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. General

(1) Food in the food-service establishment shall be from a source approved, or considered satisfactory, by the health authority. Food from such sources shall have been protected from contamination and spoilage during subsequent handling, packaging, and storage, and while in transit.

(2) All food in the food-service establishment shall be wholesome and free from spoilage, adulteration, and misbranding.

b. Milk and Milk Products:

(1) All milk and milk products, including fluid milk, other fluid dairy products and manufactured milk products, shall meet the standards of quality established for such products by applicable State and local laws and regulations.

(2) Only pasteurized fluid milk and fluid-milk products shall be used or served. Dry milk and milk products may be reconstituted in the establishment if used for cooking purposes only.

(3) All milk and fluid-milk products for drinking purposes shall be purchased and served in the original, individual container in which they were packaged at the milk plant, or shall be served from an approved bulk milk dispenser: Provided, That cream, whipped cream or half and half, which is to be consumed on the premises, may be served from the original container of not more than one-half gallon capacity or from a dispenser approved by the health authority for such service, and for mixed drinks requiring less than one-half pint of milk, milk may be poured from one-half gallon containers packaged at a milk plant.

c. Frozen Desserts:

(1) All frozen desserts such as ice cream, soft frozen desserts, ice milk, sherbets, ices, and mix shall meet the standards of quality established for such products by applicable State and local laws and regulations.

d. Shellfish:

(1) All oysters, clams, and mussels shall be from sources approved by the State shellfish authority: Provided, That if the source be outside the State, it shall be one which is certified[5] by the State of origin.

(2) Shell stock shall be identified with an official tag giving the name and certificate number of the original shell-stock shipper and the kind and quantity of shell stock. Fresh and frozen shucked oysters, clams, and mussels, shall be packed in nonreturnable containers identified with the name and address of the packer, repacker, or distributor, and the certifi-

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5. The Public Health Service issues a periodic list of shellfish shippers who have been certified by State shellfish control agencies, whose control measures have been endorsed by the Public Health Service. This list is a means whereby the health authority may be assured that all shellfish received from sources outside their jurisdiction are of a satisfactory, sanitary quality. The list can be obtained from the Public Health Service, Washington 25, D. C.

cate number of the packer or repacker preceded by the abbreviated name of the State.[6]

(3) Shucked shellfish shall be kept in the original container until used.

e. Meat and Meat Products:

(1) All meat and meat products shall have been inspected for wholesomeness under an official regulatory program: Provided, That the health authority may accept other sources which are in his opinion satisfactory and which are in compliance with applicable State and local laws and regulations.

f. Poultry and Poultry Meat Products:

(1) All poultry and poultry meat products shall have been inspected for wholesomeness under an official regulatory program: Provided, That the health authority may accept other sources which are in his opinion satisfactory and which are in compliance with applicable State and local laws and regulations.

g. Bakery Products:

(1) All bakery products shall have been prepared in the food-service establishment or in a food-processing establishment: Provided, That the health authority may accept other sources which are in his opinion satisfactory and which are in compliance with applicable State and local laws and regulations. All cream-filled and custard-filled pastries shall have been prepared and handled in accordance with the requirements of 2. c. (6) of this section.

h. Nonacid and Low-Acid Hermetically Sealed Food:

(1) All nonacid and low-acid hermetically sealed food shall have been processed in food-processing establishments.

2. Food Protection: All food while being stored, prepared, displayed, served, or sold at food-service establishments, or during transportation between such establishments, shall be protected from contamination. All perishable food shall be stored at such temperatures as will protect against spoilage. All potentially hazardous food shall be maintained at safe temperatures (45°F. or below, or 140°F. or above), except during necessary periods of preparation and service. Raw fruits and vegetables shall be washed before use. Stuffings, poultry, stuffed meats and poultry, and pork and pork products shall be thoroughly cooked before being served. Individual portions of food once served to the customer shall not be served again: Provided, That wrapped food which has not been unwrapped and which is wholesome may be re-served.

Only such poisonous and toxic materials as are required to maintain sanitary conditions and for sanitization purposes may be used or stored in food-service establishments. Poisonous and toxic materials shall be identified, and shall be used only in such manner and under such conditions as will not contaminate food or constitute a hazard to employees or customers.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. General:

(1) All food, while being stored, prepared, displayed, served, or sold in food-service establishments, or transported between such establishments, shall be protected against

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6. The health authority should check the certificate number against the current list of certified shippers. This certification requirement is not applicable to breaded or other processed shellfish.

contamination from dust, flies, rodents, and other vermin; unclean utensils and work surfaces; unnecessary handling; coughs and sneezes; flooding, drainage, and overhead leakage; and any other source.

(2) Conveniently located refrigeration facilities, hot food storage and display facilities, and effective insulated facilities, shall be provided as needed to assure the maintenance of all food at required temperatures during storage, preparation, display, and service. Each cold-storage facility used for the storage of perishable food in non-frozen state shall be provided with an indicating thermometer accurate to $\pm 2^{o}$F., located in the warmest part of the facility in which food is stored, and of such type and so situated that the thermometer can be easily and readily observed for reading.

b. Temperatures*:

(1) All perishable food shall be stored at such temperatures as will protect against spoilage.

(2) All potentially hazardous food shall, except when being prepared and served, and when being displayed for service, be kept at 45°F. or below, or 140°F. or above.

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*Note: The Engineering Section Project of the American Public Health Association recommended the following for refrigeration in 1948: Refrigerators shall be provided for all perishable food or drink at all times except as may be required when being processed, prepared or served.

(1) A maximum allowable air temperature of 40 degrees F. shall be the limit of safe storage for raw meat, raw poultry, eggs, milk, cream, cheese, and butter when the storage period is more than 24 hours but less than seven days.

(2) The maximum allowable temperature for refrigerated storage of less than 24 hours duration of any perishable food shall be 50 degrees F. unless specifically permitted otherwise under item 7 or 8 below.

(3) Storage of perishable products shall be lower than the maximum whenever it is deemed by the health officer to be necessary for the preservation of the wholesomeness of food and the protection of health of consumers of such stored food. A table of recommended retail storage temperatures shall be used by the health officer as a guide. (See tables 18 and 19.)

(4) Every food establishment including bakeries which handles perishable food or food products for sale or as raw material shall provide adequate refrigeration for such food.

(5) Poultry shall be rapidly chilled immediately after defeathering by a method approved by the health officer.

(6) Cooked foods of animal origin and food mixtures containing protein which are not held at 150 degrees F. shall be cooled as rapidly as possible to 40 degrees F. and held at a temperature of 50 degrees F. or less as required by the health officer until used.

(7) Cooked leafy vegetables and foods of low protein content may be stored for a period not exceeding two hours at not greater than 70 degrees F.

(8) Perishable foods served or intended to be served as hot food in a short period of time shall be held at not less than 150 degrees F. until served.

(9) Frozen food storage shall be in accordance with the requirements for "Frozen Foods."

(10) Thermometers shall be provided by the permit holder in all refrigerators under his jurisdiction. The temperature of the refrigerator shall be taken at a point which reflects the temperature of the stabilized air surrounding food in the upper one-quarter of the refrigerator storage section.

(3) All potentially hazardous food, when placed on display for service, shall be kept hot or cold as required hereafter:

(a) If served hot, the temperature of such food shall be kept at 140°F. or above;

(b) If served cold, such food shall be:

i Displayed in or on a refrigerated facility which can reduce or maintain the product temperature at 45°F. or below; or

ii Prechilled to a temperature of 45°F. or below, when placed on display for service, and the food temperature shall at no time during the display period exceed 55°F.

(4) Following preparation, hollandaise and other sauces which, pending service, must be held in the temperature range of 45°F. to 140°F., may be exempt from the temperature requirements of this subsection, if they be prepared from fresh ingredients and are discarded as waste within three hours after preparation. Where such sauces require eggs as an ingredient, only shell eggs shall be used.

(5) Frozen food shall be kept at such temperatures as to remain frozen, except when being thawed for preparation or use. Potentially hazardous frozen food shall be thawed at refrigerator temperatures of 45°F. or below; or under cool, potable running water (70°F. or below); or quick-thawed as part of the cooking process; or by any other method satisfactory to the health authority.

c. Preparation:

(1) Convenient and suitable utensils, such as forks, knives, tongs, spoons, or scoops, shall be provided and used to minimize handling of food at all points where food is prepared.

(2) All raw fruits and vegetables shall be washed thoroughly before being cooked or served.

(3) Stuffings, poultry, and stuffed meats and poultry, shall be heated,[7] throughout, to a minimum temperature of 165°F., with no interruption of the initial cooking process.

(4) Pork and pork products which have not been specially treated to destroy trichinae shall be thoroughly cooked to heat all parts of the meat to at least 150°F.

(5) Meat salads, poultry salads, potato salad, egg salad, cream-filled pastries, and other potentially hazardous prepared food shall be prepared (preferably from chilled products) with a minimum of manual contact, and on surfaces and with utensils which are clean and which, prior to use, have been sanitized.

(6) Custards, cream fillings, or similar products which are prepared by hot or cold processes, and which are used as puddings or pastry fillings, shall be kept at safe

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7. Depending upon the weight of the poultry, and the temperature at which cooked, a number of hours are required for the stuffing to reach a temperature, throughout, sufficiently high (165°F.) to kill pathogens which may be present. Therefore, it is recommended that the dressing be cooked in shallow pans separately from the carcass. It is further recommended that in cooking small poultry, the dressing be cooked separately from the carcass, or that it be placed in the carcass just prior to cooking.

temperatures, except during necessary periods of preparation and service, and shall meet the following requirements[8] as applicable:

(a) Pastry fillings shall be placed in shells, crusts, or other baked goods either while hot (not less than 140°F.) or immediately following preparation, if a cold process beused; or

(b) Such fillings and puddings shall be refrigerated at 45°F. or below in shallow pans, immediately after cooking or preparation, and held thereat until combined into pastries, or served.

(c) All completed custard-filled and cream-filled pastries shall, unless served immediately following filling, be refrigerated at 45°F. or below promptly after preparation, and held thereat pending service.

d. Storage:

(1) Containers of food shall be stored above the floor, on clean racks, dollies, or other clean surfaces, in such a manner as to be protected from splash and other contamination.

(2) Food not subject to further washing or cooking before serving shall be stored in such a manner as to be protected against contamination from food requiring washing or cooking.

(3) Wet storage of packaged food shall be prohibited.

e. Display and Service:

(1) Where unwrapped food is placed on display in all types of food-service operations, including smorgasbords, buffets, and cafeterias, it shall be protected against contamination from customers and other sources by effective, easily cleanable, counter-protector devices, cabinets, display cases, containers, or other similar type of protective equipment. Self-service openings in counter guards shall be so designed and arranged as to protect food from manual contact by customers.

(2) Tongs, forks, spoons, picks, spatulas, scoops, and other suitable utensils shall be provided and shall be used by employees to reduce manual contact with food to a minimum. For self-service by customers, similar implements shall be provided.

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8. To facilitate the procedures of enforcing these provisions in cases where the pastries used are not prepared in the food-service establishment, health authorities who are in a position to do so may require (by adding appropriate provisions to the ordinance or to the local bakery sanitation ordinance or regulations) that cream-filled or custard-filled pastries be wrapped, packaged, or otherwise effectively protected from contamination at the place of manufacture and prominently labeled with the name and address of the manufacturer.

8a. The cooking of a custard mixture after eggs and starch are added should result in a 99% reduction of organisms because high temperatures are used. A product having approximately one thousand colonies per gram after cooking should be acceptable.

In order to have a product with a minimum bacterial content after cooking it is recommended that custard be cooked at a temperature of at least 190°F. for ten minutes in steam jacket vessels with facilities for agitation to prevent scorching, and then cooled in the same vessel to 50°F. or less within an hour. "The Control of the Sanitary Quality of Custard Filled Bakery Products," by Samuel Plotkin, R.S., Sanitary Journal of Environmental Health, Vol. 25, No. 1, pages 34 to 38, 1962.

(3) Dispensing scoops, spoons and dippers, used in serving frozen desserts, shall be stored, between uses, either in an approved running-water dipper well, or in a manner approved by the health authority.

(4) Sugar shall be provided only in closed dispensers or in individual packages.

(5) Individual portions of food once served to a customer shall not be served again: Provided, That wrapped food, other than potentially hazardous food, which is still wholesome and has not been unwrapped, may be re-served.

f. Transportation:

(1) The requirements for storage, display, and general protection against contamination, as contained in this subsection, shall apply in the transporting of all food from a food-service establishment to another location for service or catering operations, and all potentially hazardous food shall be kept at 45°F. or below, or 140°F. or above, during transportation.

(2) During the transportation of food from a food-service establishment, all food shall be in covered containers or completely wrapped or packaged so as to be protected from contamination.

g. Poisonous and Toxic Materials:

(1) Only those poisonous and toxic materials required to maintain the establishment in a sanitary condition, and for sanitization of equipment and utensils, shall be present in any area used in connection with food-service establishments.

(2) All containers of poisonous and toxic materials shall be prominently and distinctively marked or labeled for easy identification as to contents.

(3) When not in use, poisonous and toxic materials shall be stored in cabinets which are used for no other purpose, or in a place which is outside the food-storage, food-preparation, and cleaned equipment and utensil storage rooms. Bactericides and cleaning compounds shall not be stored in the same cabinet or area of the room with insecticides, rodenticides, or other poisonous materials.

(4) Bactericides, cleaning compounds, or other compounds, intended for use on food-contact surfaces, shall not be used in such a manner as to leave a toxic residue on such surfaces, nor to constitute a hazard to employees or customers.

(5) Poisonous polishing materials shall not be used on equipment or utensils, nor stored in the establishment.

(6) Poisonous compounds, such as insecticides and rodenticides, in powered form, shall have a distinctive color so as not to be mistaken for food.

(7) Poisonous materials shall not be used in any way as to contaminate food, equipment, or utensils, nor to constitute other hazards to employees or customers.

Section C. Personnel

1. Health and Disease Controls: No person while affected with any disease in a communicable form, or while a carrier of such disease, or while afflicted with boils, infected wounds, sores, or an acute respiratory infection, shall work in any area of a food-service establishment in any capacity in which there is a likelihood of such person contaminating food or food-contact surfaces with pathogenic organisms, or transmitting disease to other individuals; and no person known or suspected of being affected with any such disease or condition shall be employed in such an area or capacity. If the manager or person in charge of the establishment has reason to suspect that any employee has contracted any disease in a communicable form or has become a carrier of such disease, he shall notify the health authority immediately.

2. Cleanliness: All employees shall wear clean outer garmets, maintain a high degree of personal cleanliness, and conform to hygienic practices while on duty. They shall wash their hands thoroughly in an approved hand-washing facility before starting work, and as often as may be necessary to remove soil and contamination. No employee shall resume work after visiting the toilet room without first washing his hands.

Reason: Clean personnel with clean habits are essential to sanitary food preparation and service. Clean hands, clean clothing, and hygienic practices reduce the likelihood of contaminating food, drink, and food-contact surfaces of equipment, utensils, or single-service articles.

Hand-washing is necessary not only before starting work and after visiting the toilet, but also at any other times when the hands have become soiled or contaminated. It must be recognized that hands often become soiled in the performance of routine duties in and about the establishment. The use of tobacco while preparing or serving food may contaminate the fingers with saliva, and may promote spitting, thereby permitting transmission of disease organisms present in the saliva to food or food-contact surfaces.

Insanitary and unsightly personal practices such as scratching the head, placing the fingers in or about the mouth or nose, or indiscriminate and uncovered sneezing or coughing may not only result in contamination of the food, but may adversely affect consumer confidence in the establishment.

Careless handling and unnecessary contact with soiled surfaces of dishes, glasses, cups, tableware, or napkins may expose employees to needless health hazards and should be avoided.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. Hand Washing:

(1) All employees shall thoroughly wash their hands and arms with soap and warm water before starting work, and shall wash hands during work hours as often as may be required to remove soil and contamination, as well as after visiting the toilet room.

(2) The hands of all employees shall be kept clean while engaged in handling food and food-contact surfaces.

(3) Employees shall keep their fingernails clean and neatly trimmed.

b. Clothing:

(1) The outer garments of all persons, including dishwashers, engaged in handling food or food-contact surfaces shall be reasonably clean.

(2) Hair nets, headbands, caps, or other effective hair restraints shall be used by employees engaged in the preparation and service of food to keep hair from food and food-contact surfaces.

c. Tobacco:

(1) Employees shall not use tobacco in any form while engaged in food preparation or service, or while in equipment and utensil washing of food-preparation areas: Provided, That designated locations in such areas may be approved by the health authority for smoking, where no contamination hazards will result.

d. Other Practices:

(1) Employees shall maintain a high degree of personal cleanliness and shall conform to good hygienic practices during all working periods.

Section D. Food Equipment and Utensils

1. Sanitary Design, Construction, and Installation of Equipment and Utensils: All equipment and utensils shall be so designed and of such material and workmanship as to be smooth, easily cleanable, and durable, and shall be in good repair; and the food-contact surfaces of such equipment and utensils shall, in addition, be easily accessible for cleaning, nontoxic, corrosion resistant, and relatively non-absorbent: Provided, That, when approved by the health authority, exceptions may be made to the above materials requirements for equipment such as cutting boards, blocks, and bakers' tables.

All equipment shall be so installed and maintained as to facilitate the cleaning thereof, and of all adjacent areas.

Equipment in use at the time of adoption of this ordinance which does not meet fully the above requirements may be continued in use if it be in good repair, capable of being maintained in a sanitary condition, and the food-contact surfaces are nontoxic.

Single-service articles shall be made from nontoxic materials.

Reason: Items of equipment and utensils which are poorly designed and constructed, and which are not kept in good repair, are difficult to clean thoroughly and are apt to harbor accumulations of food and other soil which supports bacterial growth. Also, accumulations of food or other soil in difficult-to-clean places on equipment, and in areas adjacent to equipment, may create a vermin-control problem and may tend to cause unpleasant odors.

Food poisoning has occurred as a result of the ingestion of acid food or drink which has been in contact with equipment or utensils containing such metals as cadmium, lead, and zinc. Therefore, the product-contact surfaces of equipment, utensils and single-service articles must be nontoxic.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. Design, Construction, and Materials[9]:

(1) All equipment and utensils shall be so durable under normal conditions and operations as to be resistant to denting, buckling, pitting, chipping, crazing, and excessive wear; and shall be capable of withstanding repeated scrubbing, scouring, and the corrosive action of cleaning and sanitizing agents and food with which they come in contact.

(2) Food-contact surfaces of equipment and utensils shall be smooth; shall be free of breaks, open seams, cracks, chips, pits, and similar imperfections; shall be in good repair; and shall be easily cleanable.

(3) Materials used as food-contact surfaces of equipment and utensils shall, under use conditions, be corrosion resistant, relatively non-absorbent and nontoxic: Provided, That the corrosion-resistant requirements shall not preclude the use of cast-iron as a food-contact material.

(4) Food-contact surfaces of equipment and utensils shall be free of difficult-to-clean internal corners and crevices. Threads which routinely contact food shall be of a

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9. To encourage uniformity in sanitary requirements and greater acceptance of equipment which has been constructed in accordance with sanitary principles, the Service cooperates with the National Sanitation Foundation, Automatic Merchandising Health-Industry Council, Baking Industry Sanitation Standards Committee, and the Committee for 3-A Sanitary Standards for dairy equipment, in the development of standards covering the sanitary design and construction of food equipment. The Public Health Service has recommended that the applicable design and construction criteria contained in its various food ordinances and codes be incorporated into the sanitary standards for equipment being developed by these groups.

sanitary design, and no V-type threads shall be used in such a situation.

(5) Lubricated bearings and gears of equipment shall be so constructed that lubricants cannot get into the food or onto food-contact surfaces.

(6) All food-contact surfaces, unless designed for in-place cleaning, shall be accessible for manual cleaning and for inspection either:

(a) Without being disassembled; or
(b) By disassembling without the use of tools; or
(c) By easy disassembling with the use of only simple tools kept available near the equipment, such as a mallet, a screwdriver, or an open-end wrench.

(7) Equipment intended for in-place cleaning shall be so designed and constructed that:

(a) Cleaning and sanitizing solutions can be circulated throughout a fixed system.
(b) Cleaning and sanitizing solutions will contact all interior surfaces.
(c) The system is self draining or otherwise completely evacuated.
(d) Cleaning procedures result in thorough cleaning of the equipment.

(8) Surfaces of equipment not intended for contact with food, but which are exposed to splash, food debris, or otherwise require frequent cleaning, shall be reasonably smooth; washable; free of unnecessary ledges, projections, or crevices; readily accessible for cleaning; and of such material and in such repair as to be readily maintained in a clean and sanitary condition.

(9) Cutting blocks and boards, and bakers' tables may be of hard maple or equivalent material which is nontoxic, smooth, and free of cracks, crevices, and open seams. Cutting boards shall be easily removable. Wicker or plastic breadbaskets, when suitably lined, may be used for unwrapped food.

(10) Soft solder, when used as a food-contact surface, shall be limited to joining metal or sealing seams between abutting metal surfaces; shall be of such formulation as to be nontoxic under use conditions; shall contain at least 50 percent tin; shall contain no more lead than is necessary under good manufacturing practice; and shall, consistent with good industrial practice in the refining of its constituent elements, be free of cadmium, antimony, bismuth, and other toxic materials.

(11) Hard solder (silver solder), when used as a food-contact surface, shall be of such formulation as to be nontoxic under use conditions; shall be corrosion resistant; and shall, consistent with good industrial practice in the refining of its constituent elements, be free of cadmium, antimony, bismuth, and other toxic materials.

(12) Single-service articles shall be made from nontoxic materials.

b. Equipment Installation:

(1) Equipment which is placed on tables or counters, unless readily movable, shall be sealed thereto or mounted on legs or feet at least 4 inches high, and shall be so installed as to facilitate the cleaning of the equipment and areas adjacent thereto.

(2) Floor-mounted equipment, unless readily movable, shall be sealed to the floor; or shall be installed on raised platforms of concrete or other smooth masonry in such a manner as to prevent liquids or debris from seeping or settling underneath, between or behind such equipment in spaces which are not fully open for cleaning and inspection; or such equipment shall be elevated at least 6 inches above the floor. The space between adjoining units, and between a unit and the adjacent wall, shall be closed unless exposed to seepage, in which

event it shall be sealed; or sufficient space shall be provided to facilitate easy cleaning between, behind, and beside all such equipment.

(3) Aisles or working spaces between equipment, and between equipment and walls, shall be unobstructed, and of sufficient width to permit employees to perform readily their duties without contamination of food or food-contact surfaces by clothing or through personal contact.

c. Existing Equipment:

(1) Equipment which was installed in a food-service establishment prior to the effective date of this ordinance, and which does not meet fully all of the design and construction requirements of this section, shall be deemed acceptable in that establishment if it be in good repair, capable of being maintained in a sanitary condition, and the food-contact surfaces are nontoxic. Such equipment shall be so located and installed as to enable reasonable compliance with all of the requirements of this subsection pertaining to equipment installation, and all of the requirements pertaining to food protection.

[Plans for kitchen layout* (See Figure 2)

Items to be checked in reviewing plans for restaurants

1. Layout with regard to work flow: Dirty dishes, clean dishes, cooked food, food being prepared.

2. Drainage: Near dishwashing, kettles, steamers, peelers, and soda fountains; from refrigeration equipment, in bathrooms, in relation to floor clearing, coved wall-floor joints.

3. Electrical outlets: Dishwashing machine, refrigerator, peeler, chopper, slicer, saw, tenderizer, fans.

4. Water outlets: Dish and pot sink, handwashing basins, salad sinks, garbage room, for general floor cleaning, peeler, evaporative cooler, ice cream dipper well, dishwashing machine.

5. Miscellaneous requirements for construction, placement, and adequacy of items: Proper number of sinks, size of clean and dirty tables, handwashing basins, outside ventilation, non-direct opening doors, locker facilities, sloping window ledges, outward opening doors, hood design and filters, refuse storage areas inside and outside, can washing facilities, refrigeration space, storage space, deep freeze space, use of National Sanitation Foundation standards for equipment, if possible.

Basic Principles of Kitchen Layout

1. General Rule of Thumb: Areas should be related to each other in the kitchen so as to promote efficient operation. Overlapping areas cause a waste of work time and create safety hazards. Proper layout makes cleaning easy and allows clear-cut designation of responsibility for area clean-up.

2. Work Areas:

a. Food delivery and storage should be located together near delivery exit. Managers desk should be close to this area.

b. Dishwashing area should be located conveniently to dish storage area, and also to the dining room in order to limit travel of waitresses through kitchen. The pot sink need not be in this area. Ventilation should be good.

c. Food pick-up area should be close to dining room, and together with the order-placing spots should be arranged to prevent traffic confusion at food preparation area.

d. Food preparation area: The cook acts as the heart of the kitchen. All equipment must be conveniently placed. This area includes the cook's, baker's, butcher's places, and the salad preparation place. The salad table, refrigerator, and sinks must be close to the salad preparation place, and the latter must be close to the serving table.

e. Toilet facilities should be convenient to employees and, possibly, to patrons, but patrons should not have to pass through kitchen to get to toilet.

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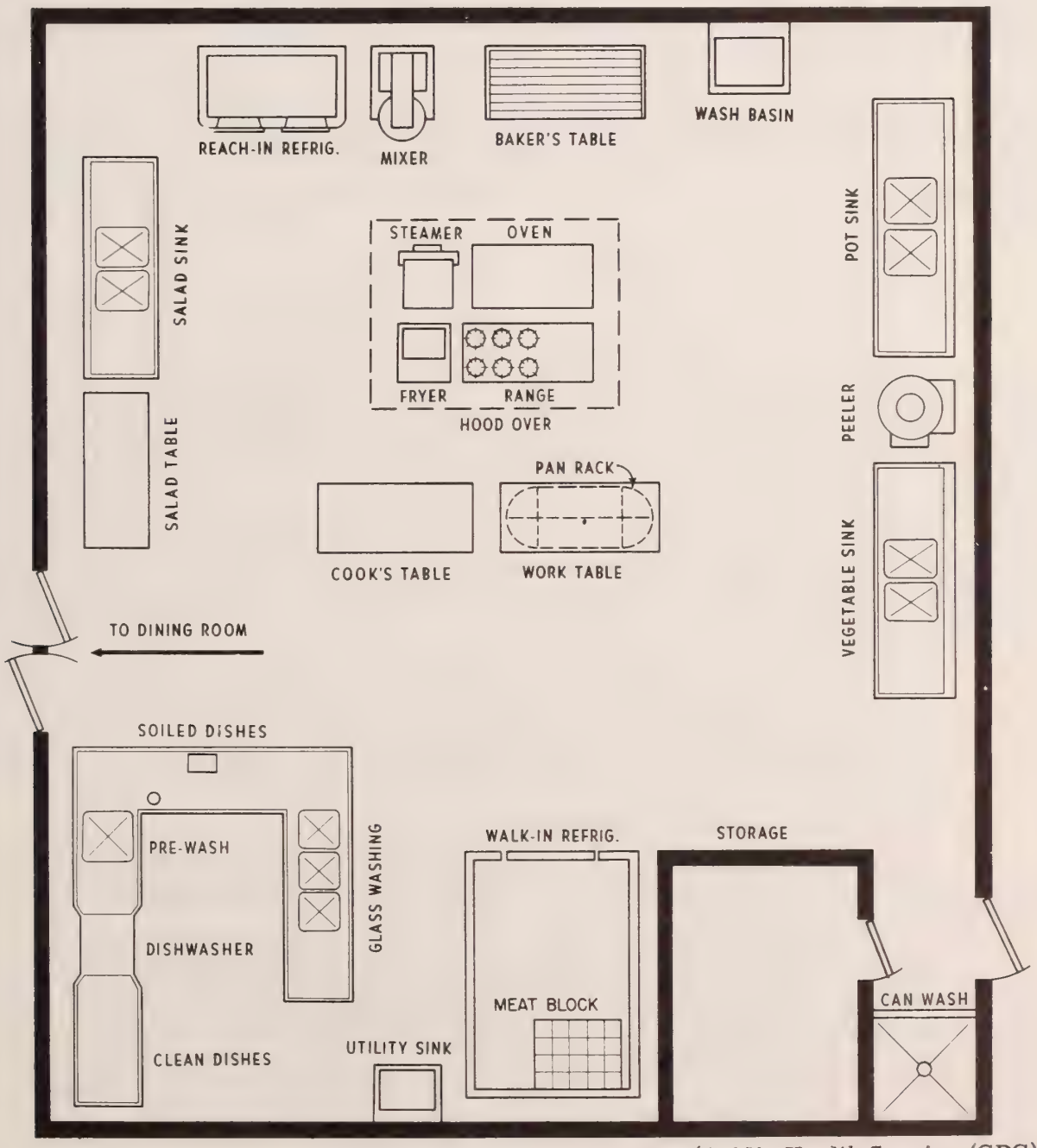
*Insert

f. Handwashing facilities should preferably be both in toilet and kitchen. If a sink be convenient, it will be used more often.

g. Locker facilities should be near toilet.

h. Refuse storage and can washing facilities should be convenient to pick-up.

i. Doors and window openings should be adequate but not wasteful of wall space. There should be a rear exit for deliveries. For general ventilation of kitchens, an air change every two minutes should be a minimum requirement. Usually, the amount of air exhausted through the range hood will be sufficient to give this number of air changes. The locations of air inlets, if a centrifugal blower be used to exhaust the air, should be placed to get uniform air movement. Where the dining room is not air-conditioned the air should be drawn from there.] (End of insert.)



(Public Health Service (CDC)

Fig. 2. EXAMPLE OF LAYOUT OF KITCHEN EQUIPMENT

2. Cleanliness of Equipment and Utensils: All eating and drinking utensils shall be thoroughly cleaned and sanitized after each usage.

All kitchenware and food-contact surfaces of equipment, exclusive of cooking surfaces of equipment, used in the preparation or serving of food or drink, and all food-storage utensils, shall be thoroughly cleaned after each use. Cooking surfaces of equipment shall be cleaned at least once a day. All utensils and food-contact surfaces of equipment used in the preparation, service, display, or storage of potentially hazardous food shall be thoroughly cleaned and sanitized prior to such use. Non-food-contact surfaces of equipment shall be cleaned at such intervals as to keep them in a clean and sanitary condition.

After cleaning and until use, all food-contact surfaces of equipment and utensils shall be so stored and handled as to be protected from contamination.

All single-service articles shall be stored, handled, and dispensed in a sanitary manner, and shall be used only once.

Food-service establishments which do not have adequate and effective facilities for cleaning and sanitizing utensils shall use single-service articles.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. Equipment and Utensil Cleanliness:

(1) After each usage, all tableware shall be thoroughly cleaned to sight and touch.

(2) After each usage, all kitchenware and food-contact surfaces of equipment, exclusive of cooking surfaces, used in the preparation, serving, display, or storage of food, shall be thoroughly cleaned to sight and touch. The cooking surfaces of grills, griddles, and similar cooking devices shall be cleaned at least once a day, and shall be free of incrusted grease deposits and other soil.

(3) Non-food-contact surfaces of all equipment used in the operation of a food-service establishment, including tables, counters, shelves, mixers, grinders, slicers, hoods, and fans, shall be cleaned at such frequency as is necessary to be free of accumulations of dust, dirt, food particles, and other debris.

(4) Detergents and abrasives shall be rinsed off food-contact surfaces.

(5) Cloths used by waiters, chefs, and other personnel, shall be clean, and any such cloths used for wiping food-contact surfaces shall be used for no other purpose.

b. Equipment and Utensil Sanitization:

(1) All tableware shall, after each use, be sanitized. A spoon or other utensil, once used for tasting food, shall not be reused until it has been cleaned and sanitized.

(2) All kitchenware and food-contact surfaces of equipment used in the preparation, service, display, or storage of potentially hazardous food shall be sanitized prior to such use, and following any interruption of operations during which contamination of the food-contact surfaces is likely to have occurred. Where equipment and utensils are used for the preparation of potentially hazardous food on a continuous or production-line basis, the food-contact surfaces of such equipment, and utensils shall be cleaned and sanitized at intervals throughout the day on a schedule approved by the health authority.

c. Methods and Facilities for Washing and Sanitizing:

(1) Prior to washing, all equipment and utensils shall be preflushed or prescraped and, when necessary, presoaked to remove gross food particles and soil.

(2) Effective concentrations of a suitable detergent* shall be used in both manual and mechanical dishwashing.

(3) When manual dishwashing is employed, equipment and utensils shall be thoroughly washed in a detergent solution which is kept reasonably clean, and then shall be rinsed free of such solution. All eating and drinking utensils and, where required, the food-contact surfaces of all other equipment and utensils shall be sanitized by one of the following methods:

(a) Immersion for at least one-half minute in clean hot water at a temperature of at least 170°F.

(b) Immersion for a period of at least 1 minute in a sanitizing solution[10] containing:

i At least 50 ppm. of available chlorine at a temperature not less than 75°F., or

ii At least 12.5 ppm. of available iodine in a solution having a pH not higher than 5.0 and a temperature of not less than 75°F.; or

iii Any other chemical-sanitizing agent which has been demonstrated to the satisfaction of the health authority to be effective and nontoxic under use conditions, and for which a suitable field test is available. Such sanitizing agents, in use solutions, shall provide the equivalent bactericidal effect of a solution containing at least 50 ppm. of available chlorine at a temperature not less than 75°F.[11]

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*Detergents: A good detergent should have the following properties:

1. Wetting: the ability to wet readily the utensil being cleaned.
2. Emulsification: the ability to emulsify the fats from the food soil on the utensils.
3. Dissolving: the ability to dissolve food materials, principally proteins.
4. Deflocculation: the ability to break up dirt particles.
5. Dispersion: the ability to function properly in hard or soft waters, and preferably to minimize the formation of a film or deposit of mineral salts and similar substances on the utensils and equipment. This property of film-prevention is called dispersion because the products of the chemical reaction between the detergent and the hardness constituents of the water are kept dispersed in the solution and their precipitation, with consequent formation of film, is minimized.
6. Biodegradation: the ability of the detergent to degrade chemically in a reasonably short period of time after becoming liquid waste in order not to become a difficult problem in water pollution.
7. Rinsing: the ability of being easily rinsed off the utensil by clean water.

10. It is recommended that, when made up, the strength of sanitizing solutions be at least twice the minimum strength required for the particular sanitizing solution used.

11. Bactericides which, in recommended concentration, produce a 99.999 percent kill of 75-125 million E. coli ATTC 11229 and of 75-125 million M. pyogenes var. aureus FDA 209 per ml. within 30 seconds, at 70°-75°F., should be considered satisfactory. (Note: Studies have shown that, in general, the efficiency of all bactericidal agents is affected by the (1) concentration of bactericidal agent, (2) time of contact between bactericidal agent and organism, (3) temperature at which contact is made, (4) pH of the water bearing the bactericidal agent, and (5) interfering substances, organic or inorganic, in the waters in which the bactericidal agents are used. Items (1) to (3), and with a little knowledge of chemistry, item (4), can be regulated by the operator. Item (5) can not be regulated by the operator. In practice he must use the tap water available, regardless of its possible content of interfering substances. This fact introduces problems which must be considered in the use of any bactericidal agent. The only satisfactory solution for the use of such bactericidal agents is to base the dosage and the quality of solutions in use, on an easily performed residual test which measures the residual bactericidal agent in terms of its bactericidal efficiency.

(c) Equipment too large to treat by methods (a) and (b) above may be treated:

i With live steam from a hose, in the case of equipment in which steam can be confined; or

ii By rinsing with boiling water; or

iii By spraying or swabbing with a chemical sanitizing solution of at least twice the minimum strength required for the particular sanitizing solution when used for immersion sanitization.

(4) A three-compartment sink shall be provided and used wherever washing and sanitization of equipment or utensils are conducted manually: Provided, That establishments where the only utensils to be washed be limited to spatulas, tongs, and similar devices, and when the only equipment to be cleaned is stationary and does not require disassembly for proper cleaning, a one-compartment sink may be approved by the health authority for this purpose. At least a two-compartment sink shall be provided and used for washing kitchenware and equipment which does not require sanitization. Single compartment utility sinks, such as cooks' and bakers' sinks, may be used for the rinsing of utensils.

(5) Sinks used for manual washing and sanitizing operations shall be of adequate length, width, and depth to permit the complete immersion of the equipment and utensils, and each compartment of such sinks shall be supplied with hot and cold running water. Dish baskets shall be of such design as to permit complete immersion of the utensils and equipment components being sanitized therein.

(6) When hot water is used as the sanitizing agent in manual operations, thermometers, accurate to $\pm 2^{\circ}$F., shall be provided convenient to the sink to permit frequent checks of the water temperature.

(7) Dish tables and drainboards, of adequate size for proper handling of soiled utensils prior to washing and for cleaned utensils following rinsing or sanitization, shall be provided, and shall be so located or constructed as not to interfere with the proper use of the dishwashing facilities: Provided, That drainboards shall not be required for cooks' and bakers' rinse sinks.

(8) Sinks, dish tables, and drainboards shall be constructed of galvanized metal or better, suitably reinforced, of such thickness and design as to resist denting and buckling, and sloped so as to be self-draining.

(9) Dishwashing machines shall be of such materials and so designed and constructed as to be easily cleanable and shall be capable, when operated properly, of rendering all surfaces of equipment and utensils clean to sight and touch, and sanitized.

(10) When spray-type dishwashing machines are used, the following additional requirements shall be met:

(a) Wash water shall be kept reasonably clean, and rinse-water tanks shall be so protected by distance, baffles, or other effective means as to minimize the entry of wash water into the rinse water.

(b) The flow pressure shall be not less than 15 or more than 25 pounds per square inch on the water line at the machine, and not less than 10 pounds per square inch at the rinse nozzles. A suitable gage cock shall be provided immediately upstream from the final rinse sprays to permit checking the flow pressure of the final rinse water.

(c) The wash-water temperature shall be at least 140°F. and in single-tank conveyor machines shall be at least 160°F. When hot water is relied upon for sanitization, the final or fresh rinse water shall be at a temperature of at least 180°F. at the entrance of the manifold. When a pumped rinse is provided, the water shall be at a temperature of at least 170°F. When chemicals are relied upon for sanitization, they shall be of a class or type ap-

proved by the health authority, and shall be applied in such concentration and for such a period of time as to provide effective bactericidal treatment of the equipment and utensils.

(d) Conveyors in dishwashing machines shall be accurately timed to assure proper exposure times in wash and rinse cycles.

(e) An easily readable thermometer shall be provided in each tank of the dishwashing machine which will indicate to an accuracy of $\pm 2^{\circ}$F. the temperature of the water or solution therein. In addition, a thermometer of equal accuracy shall be provided which will indicate the temperature of the final rinse water as it enters the manifold.

(f) Jets, nozzles, and all other parts of each machine shall be maintained free of chemical deposits, debris, and other soil. Automatic detergent dispensers, if used, shall be kept in proper operating condition.

(11) When an immersion-type dishwashing machine is employed for equipment and utensil washing and sanitizing, the applicable requirements pertaining to manual dishwashing shall be met: Provided, That a two-compartment system shall be deemed adequate when the temperature of the wash water is maintained at or above 140°F. and hot water at a temperature of at least 170°F. is used as the sanitizing agent.

(12) Any other type of machine, device, or facilities and procedures may be approved by the health authority for cleaning or sanitizing equipment and utensils, if it can be readily established that such machine, device, or facilities and procedures will routinely render equipment and utensils clean to sight and touch, and provide effective bactericidal treatment as demonstrated by an average plate count per utensil surface examined, of not more than 100 colonies.

[*Quaternary ammonium compounds (QAC) are now being marketed that are effective disinfectants in waters of widely varying mineral content, particularly hardness, when such disinfectants are properly used. For example, most quaternaries being marketed are effective through a range of 500 ppm. hardness of water.

Test procedures including the utilization of test papers of the color change type have been developed to give results within acceptable accuracy limits (See test as outlined below).

Quaternary ammonium compounds should be considered acceptable as a final sanitizing rinse provided that:

1. A report of the hardness of the water being used be on file and that the hardness does not exceed 500 ppm.

2. The solution has been prepared from a product which carries a label statement that it be effective in waters of up to 500 ppm. hardness.

3. The sanitizing solutions shall:
   a. have a quaternary compound concentration of 200 ppm. or greater.
   b. have a pH level of 6.0 or higher.
   c. have a minimum temperature of 75°F.
   d. have a contact period with items to be sanitized of not less than 2 minutes.
   e. remain clean and free of organic matter carried over from the washing operation.

4. An approved field test for checking QAC residual in the sanitizing rinse solution be used. There is no single field test suitable for all types of QAC. The field test apparatus and procedure used should be that which is recommended by the manufacturer of the QAC for his product, provided that the test be acceptable to the Board of Health.

5. There be no carry-over of detergents from the washing operation that would neutralize the QAC. In certain operations, an anionic wetting agent in a detergent could carry over and

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*Insert

neutralize cationic QAC.

6. The water be free from organic matter since the stability of QAC in the presence of organic matter is about equivalent to that of hypochlorites. This, of necessity, makes the use of a three compartment sink essential.

7. There exist little possible chance for any of the solution to be consumed by any human being in food or drink.

Iodophors should be considered acceptable for use as a final sanitizing rinse provided that:

1. The concentration of the bactericide as recommended on the label will produce a 99.999 percent kill of 75-125 million E. coli AATC 11229 and of 75-125 million M. pyrogenes var. aureus FDA 209 per ml., within 30 seconds at 70°-75°F.

2. The sanitizing solution provides the following:
   a. A concentration of at least 25 ppm. available iodine, since a concentration of less than 12.5 ppm. is inadequate for sanitization.
   b. A pH of 4.0 or less.

3. There be an exposure period of at least two minutes except for short time glass-washing machines.

4. There be an acceptable field test for checking the iodine residual in the solution. The self-indicating feature of the iodophors is a valuable asset but should not be accepted in lieu of an adequate field test procedure.

5. There be no carry-over from the washing operation of an incompatible detergent which might neutralize the iodophor.

6. There be an assurance that the solution remain free of organic matter.

7. The compound be acceptable to the Board of Health.

Field Test for Quaternary Ammonia Compounds: The basis of this field test which was developed by the Sterling-Winthrop Research Institute,* is a tablet containing an anionic reagent and a mixture of color indicators. Each tablet contains exactly the correct amount of anionic reagent to inactivate 8 ml. of a 200 ppm. solution of benzalkonium chloride (Roccal), used as a standard here, or the equivalent of this amount as determined by the molecular weight of any other quaternary ammonia sanitizer.

If the test solution should contain less than this recommended amount, the test results in a reddish-brown color. If the test solution contains the recommended amount of sanitizer (or more), the excess over that inactivated by the anionic reagent then alters the color of the indicators so as to yield a bluish-green. The color shift at the equivalence point is effected by small changes in quaternary ammonium compound concentration, so that the end point is relatively sharp.

If the reddish-brown color appears when a tablet is dissolved in 8 ml. of test solution, the test can be extended by adding 1 or 2 ml. of test solution to the original 8 ml. in the graduate. If there be a shift from reddish-brown to a bluish-green color when the volume in the graduate reaches 9 or 10 ml., a benzalkonium chloride concentration of 177 ppm. or 160 ppm. respectively, will be indicated, i.e.,

$$9 \text{ ml.}: \ 200 \text{ ppm.} :: 8 \text{ ml.} : x$$
$$x = 177 \text{ ppm.}$$
$$10 \text{ ml.}: \ 200\,x :: 8 \text{ ml.}: x$$
$$x = 160 \text{ ppm.}$$

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* The Sanitarian's Journal of Environmental Health, Vol. 25, 187-189, 1962.

Although the Roccal Test Tablets* are designed particularly for determining concentrations of benzalkonium halides, they may be employed to examine solutions containing other quaternary ammonium compounds. To do so, it is only necessary to know the molecular weight of the other quaternary. The simplest way to adjust for any difference in molecular weight (or the molecular weight in the case of a mixture of quaternary ammonium compounds) of the quaternary ammonia other than that of benzalkonium chloride is to calculate how much volume of test solution is equivalent, on the molar basis, to the 8 ml. of benzalkonium chloride. Then use this amount for performing the test. The calculation is as follows where QAC stands for quaternary ammonia compound, MW stands for molecular weight, the 8 stands for the 8 ml. of standard QAC, and 357 is the molecular weight of benzalkonium chloride (the standard QAC used):

$$\frac{\text{MW of test QAC} \times 8}{357} = \text{Volume of QAC test solution}$$

Example: How much solution of lauryl-dimethyl-benzyl-ammonium chloride having a molecular weight of 339.5, will be required per test tablet to determine whether its level of concentration is at least 200 ppm. ?

$$\frac{339.5 \times 8}{357} = 7.6 \text{ ml. of lauryl-dimethyl-benzyl-ammonia chloride}$$

For certain applications, the recommended concentration of quaternary ammonia may be greater than 200 ppm. Such stronger solutions may be tested with the Roccal Test Tablets by diluting the particular solution with the amount of water calculated to reduce the QAC solution to 200 ppm. based on the molecular weight of the QAC, then testing the calculated volume of the diluted test solution as described above with one reagent tablet. The indicated concentration is then multiplied by the dilution factor to obtain the concentration of the original solution. The following table gives various volumes of test solution that should be used to determine whether the test solution meets the required concentration level recommended for the particular QAC usage. This table is an aid to the calculation described above.

Table 20

Concentration (ppm)		Volume of Test Solution						
		200	400	600	800	1,000	1,600	2,000
Molecular weight	331	7.4	3.7	2.5	1.8	1.5	0.92	0.74
	357	8.0	4.0	2.7	2.0	1.6	1.00	0.80
	378	8.5	4.2	2.8	2.1	1.7	1.06	0.85
	384	8.6	4.3	2.9	2.1	1.7	1.07	0.86
	419	9.4	4.7	3.1	2.4	1.9	1.18	0.94

[**Dishwashing Machines: Recommended Minimum Requirements for Effective Dishwashing-Committee on Sanitary Engineering and Environment - Subcommittee on Food Supply, American Public Health Association.

Status: This is a tentative functional specification designed to incorporate the results of recent studies of the efficiency of mechanical dishwashers.

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* USP 2979468, issued April 11, 1961 to Sterling Drug Inc., assignee of Morris E. Auerbach and Robert S. Browning.

**Insert continued. See section "Guide for the Field Evaluation of Dishwashing Machines" in this Chapter.

Table 21 Wash and Rinse Specifications for Spray Type Dishwashing Machines

Wash and Rinse Specifications
For Spray Type Dishwashing Machines
Abstracted from National Sanitation Foundation Standards, No. 3, 1956

	Single Tank, Stationary Rack, Hood, Curtain and Door Type				Single Tank Conveyor Type (Pre-flushed dishes)	Multiple Tank Conveyor Type with Dishes in Inclined Position on Conveyor or in Rack (Pre-flushed dishes)		Multiple Tank Conveyor Type with Dishes Flat on Conveyor (Pre-flushed dishes	
Wash Cycle									
Wash area size	20" x 20" rack	18" x 18" rack	16" x 16" rack	Other rack sizes	20" was area width[5]	20" wash area width[5]		20" wash area width[5]	
Water temperature	140°F. to 160°F.	140°F. to 160°F.	140°F. to 160°F.	140°F. to 160°F.	160 F.°or more	140°F. to 160°F.		140°F. to 160°F.	
Required volume of water	92 gals.	75 gals.	60 gals.	Rack area x 0.23	3 gals. per lineal inch of conveyor	1.65 gals. per lineal inch of conveyor		0.5 gals. per lineal inch of dish travel	
Time	40 seconds	40 seconds	40 seconds	40 seconds	15 seconds for a point to traverse the wash spray area	7 seconds for a point to traverse the wash spray area		4 seconds for a point to traverse the wash spray area	
Pump delivery capacity	140 gals. per minute[1]	112 gals. per minute[2]	90 gals. per minute[3]	Rack area x 0.35[4]	Not less than 140 gals. per minute	Not less than 125 gals. per minute		Not less than 100 gals. per minute	
Pump minimum capacity	75 gals. per minute	50 gals. per minute	40 gals. per minute	Rack area x 0.15					
Pressure at nozzle					Sufficient to deliver water to all dish surfaces with cutting velocity				
Rinse Cycle						Final	Recirculated	Final	Recirculated
Time	10 seconds	10 seconds	10 seconds	10 seconds	Conveyor movement of not more than 7 ft. per minute		7 seconds for a point to traverse the spray area		4 seconds for point to traverse the rinse area
Volume of water	1.5 gals. per rack	1.25 gals. per rack	1.0 gals. per rack	0.375 gals. per 100 sq. inches	Not less than 6 gals. per minute			Based on conveyor speed of not more than 16 sq. ft. per minute	
Water temperature	180°F. at entrance of manifold		180°F. at entrance of manifold		180°F. to 210 F. at entrance of manifold	Not less than 180°F. at entrance of manifold	170°F. or more	180°F. or more at entrance of manifold	170°F. or more
Flow pressure	Line: not less than 15 lbs. nor more than 25 lbs. per square inch Nozzle: not less than 10 lbs. nor more than 25 lbs. per square inch						Nozzle: Cutting velocity	Same as for conveyor with inclined position of dishes	Sufficient to deliver water to all dish surfaces
Pump delivery capacity						Not less than 4 gals. per minute	Not less than 125 gals. per minute	Not less than 5 gals. per minute	Not less than 100 gals. per minute
Required volume of water							1.65 gals. per lineal inch for 20" rinse area[5]		0.5 gals. per lineal inch of dish travel in rinse area of 20" width[5]
Other requirements						Conveyor speed not more than 15 ft. per minute	No intermingling of rinse and wash spray		No intermingling of rinse and wash spray

(1) For less than this, the time of washing is increased to apply not less than 92 gals. of water per rack
(2) " 75 " " " " "
(3) " 60 " " " " "
(4) " requires gals. of water per rack
(5) For width of more or less than 20", the water volume shall be proportional

Objective: To treat soiled eating and drinking utensils so as to remove all visible soil, wash water, and detergent, leave them clean and reasonably dry, and effectively reduce the public health hazard.

Scraping: Food remains shall be removed from the dishes by hand or suitable mechanical device.

Preflushing: The preflushing of dishes with warm water, with or without detergent, is highly desirable. This may be done in a preflush section of the dishwashing machine of demonstrated effectiveness or as a separate operation. The warm water containing detergent overflowing from the wash water tank or overflow rinse water may well be utilized for preflushing.

Racks and Racking: The dish racks shall be of such design as to minimize masking of the sprays. Construction with non-marking corrosion-resistant welded wire is recommended. The number of each type of utensil per rack shall be limited as overcrowding prevents effective washing. A sufficient number of racks shall be provided to permit continuous operation under maximum load. Means shall be provided for returning empty racks without damage or contamination from the outlet to the inlet end of the machine.

Washing: The temperature of the wash water shall be not less than 140°F. with good preflushing, higher temperatures, i.e., 160°F. or more are desirable. Means shall be provided to maintain the temperature of the wash water at not less than 140°F.

The degree of temperature that would be effective for sanitizing dishes is related to the length of time the dishes are exposed. The temperature attained by the water in the actual operation of dishwashing machines may vary. In order to give the sanitarian an instrument for determining the exposure time required at various water temperatures, Chart 1 was devised by interpolation, therefore the time-temperature points are approximate. They are safe, however, being adjusted by a safety factor.

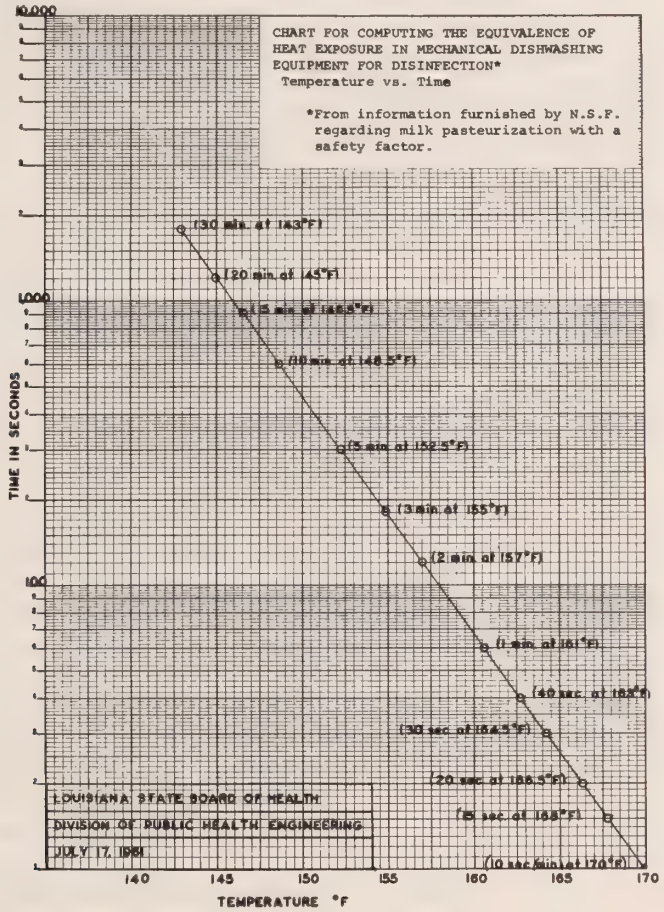

Chart 1

The minimum time of washing shall be 20 seconds, during which time each rack of dishes shall be sprayed from above and below in about equal amounts with a total of not less than 12 gallons of wash water per 100 square inches of tray area under not less than three pounds flow pressure at the top manifold.

In single tank machines the time of washing shall be controlled automatically at not less than 40 seconds and in multiple tank machines such time shall be controlled at not less than 20 seconds by timed conveyors with effective method to prevent racks from being pushed through.

Means should be provided to maintain the concentration of detergent in the wash water automatically and continuously at not less than 0.1 percent by weight in excess of that necessary to satisfy the hardness of the water.

In multiple-tank dishwashing machines, excessive spilling or carry-over of water shall be prevented by providing at least 15 inches of space between the beginning of the wash tank and the center of the first spray arm opening, at least 20 inches between the centers of the last wash spray arm opening and the first rinse spray arm opening, at least 5 inches between the center of the last rinse spray arm opening and the curtain rinse opening, and not less than 10 inches between the center of the last curtain rinse spray opening and the end of the rinse tank. When necessary, because of extended spray patterns or otherwise, baffles shall be installed

between the wash and rinse tanks to prevent further intermingling of wash and rinse waters.

Rinse: A power or recirculated rinse (two-tank machine) is desirable wherever the quantity of utensils to be washed justifies the cost and space available for installation permits. The temperature of such rinse water shall be not less than 180°F. at the inlet to the spray arm. The minimum time of rinsing shall be 10 seconds, during which time each rack of dishes shall be sprayed from above and below in about equal amounts with a total of not less than 12 gallons of rinse water per 100 square inches of area under not less than 3 pounds flow pressure at the nozzles. Where this rinse is used as the sanitizing rinse, provision shall be made to stop the machine automatically and to display a warning light whenever the temperature of the rinse water drops below 180°F. A key-operated device shall be provided to permit starting and operating the machine in emergencies at less than the recommended temperature.

When a recirculated rinse is not provided, as in a single-tank machine, the fresh water rinse from the pressure line shall be maintained at a temperature of not less than 180°F. at the inlet to the spray arm and provided with automatic stop and warning light as above. The minimum time of rinsing shall be 10 seconds during which time each rack of dishes shall be sprayed with no less than 3.8 gallons of fresh water per 100 square inches of area under not less than 15 pounds flow pressure at the nozzles. Provision shall be made to stop the machine automatically and to display a warning light whenever the temperature of this rinse water drops below 180°F. A key operated device shall also be provided for emergency operation.

Curtain Rinse: A curtain rinse may be provided on each multiple tank machine but is insufficient for use on single tank machines. Such rinse shall use not more than 2 gallons of water per minute maintained at 180°F. or more at the inlet to the spray arm.

Removal of Vapors: Where excessive moisture accumulates and causes condensation, the installation should include suitable means for ventilation and removal of the excess vapor.

Valves: The water and steam valves shall be of dependable construction, easily accessible, marked with standard designating colors in accordance with A.S.A.: A 13-1928 "Scheme for the Identification of Piping System," labeled as to purpose, and shall not so protrude as to be easily broken off. Valves shall be suitable for the purpose and built to withstand 125 pounds operating pressure. The water valves shall be of globe type with removable seats.

Thermometers: A dial type thermometer with 180°F. visibly marked, showing final rinse water temperature, shall be installed at eye level near the discharge end of the machine where it is protected against breakage. The bulb shall be located so as to show the temperature of rinse water entering the spray arm. Similarly, a thermometer shall be installed to show the wash water temperature.

Pressure Gauges: Gauges shall be provided to show the flow pressure as near as practical to the spray arm openings of both the wash and rinse water systems.

Scrap Trays: Scrap trays shall have openings smaller than those in the spray arm and shall be readily accessible and removable for cleaning. A strainer, accessible for cleaning, shall also be provided on the pump suction.

Spray Arms: Spray arms shall be made of material that is relatively non-corrodible in warm detergent solution and shall be easily removable and accessible for cleaning. The slots or jet openings shall be large enough not to clog easily and shall be so placed as to completely spray every part of every utensil in racks of the standard size delivered with the machine.

Either the spray arms shall move or the dish racks shall be moved during washing and rinsing to increase the coverage of the sprays.

Construction: The tanks and hoods shall be constructed of monel metal, stainless steel or equally corrosion-resistant material in such a manner as to be easily cleaned.

Sharp angles, unnecessary ledges, and open seams shall be eliminated. To facilitate clean-

ing of the interior, consideration shall be given to locating as much of the piping as possible on the exterior of the dishwashing machine.

Each tank including the pump, shall be easy to drain. The pump suction shall be at least 2 inches above the bottom of the tank.

Each tank shall be provided with a water level indicator.

The supporting frame, motors, and pumps shall be of smooth construction with all parts accessible for cleaning. Adequate guards shall be placed over moving parts.

The bottom platform of the machine shall be not less than 6 inches off the floor.

Side clean-out doors or removable panels not less than 16 inches in width shall be provided for convenience in cleaning the tanks.

Conveyors shall be so timed that the fixed speed will provide at least the minimum holding times herein specified for the various operations.

Water Supply: Water meters that are too small and water mains that are too badly encrusted to deliver sufficient water for the sanitizing rinse under the existing conditions of installation are a frequent cause of failure of dishwashing operations.

When the hardness of the water exceeds 5 grains, a hard water detergent should be used; when it exceeds 100 grains, softening to 5 grains or less is recommended.

In order to secure uniform water pressure, the installation of a pressure-reducing valve on the hot water line to the fresh water rinse of the dishwashing machine is recommended, so set as to give 15 pounds flow pressure at the upper rinse arm openings while in operation.

The water connections to the dishwashing machines shall be so made as to prevent back-siphonage of dish water, sewage or wastes.

The hot water storage tank shall be of ample capacity and the heater shall have sufficient recovery capacity to supply the amount of water, at not less than 140°F., needed for maximum length dishwashing periods and other operations for which it is designed to provide water, if carried on simultaneously.

A booster heater shall be provided close to the point of application at the dishwashing machine for each fresh water rinse, and shall be of sufficient capacity to provide water at the rate of not less than 4 gallons per 100 square inches of tray area per minute at 180°F. or higher at the inlet to the spray arm for a single tank machine and 2 gallons or less per minute of 180°F. water for each curtain rinse on a multiple tank machine.

High Temperature Water: For sanitizing rinses, water is required at temperatures higher than that at which it is customary or considered safe to carry water in storage tanks for the general hot water supply. For such uses, demanding water at not less than 180°F., a separate heater and storage tank may be used, or a two-stage heater, or an auxiliary or booster heater. Because of the necessary intermittancy in the use of sanitizing rinses, installations should include definite provisions for preventing the cooling below 180°F. of water in pipelines between heaters or storage tanks and the dishwashing machines as by recirculation. Adequate and dependable thermostatic controls shall be installed and used to maintain such hot water supply at not less than 180°F.

Placing: The machine shall be so installed that all parts are easily accessible for repair, servicing, or replacement.

Operating Instructions: Complete operating instructions shall be provided. Such instructions shall stress draining the tanks empty after the dishes from each meal are finished, cleaning the tanks and spray arms, and leaving them dry until the next use.

Detergents. (1) Is the detergent dispenser charged and functioning properly? (2) Is the detergent an effective cleaner in the water used?

Pumped rinse. (1) If there be a pumped rinse, is the water maintained at the recommended temperature? (2) Are the spray jets for the pumped rinse clean and do the sprays appear to be adequate and well distributed? (3) Is the pumped rinse properly timed?

Fresh Water rinse. (1) Is the temperature of the fresh water rinse at the manifold consistently maintained at not less than 180°F. nor more than 210°F. ? (2) With all nearby water outlets as well as the fresh water rinse sprays turned on, is the flow pressure in the hot water line at the machine at least 15 pounds and not over 25 pounds, or at operating pressure recommended by the manufacturer? (3) Are the fresh water rinse jets clean and do the sprays appear to be adequate and well distributed? (4) Is the fresh water rinse of the required duration adjustment?

Inspection of Operations

The dishwashing machine operation inspector should use the National Sanitation Foundation Standard No. 3 as the guide for dish machine design and installation. For hot water heating facilities, N.S.F. Standard No. 5 should be used as the criterion of compliance.

Testing Equipment

The basic items for testing equipment are a pyrometer and a pressure gauge. The pyrometer should have a range of 50° to 400°F. with an accuracy ± 2°F.

Pressure may be determined with a Bourdon tube type pressure gauge calibrated to measure pressure from 0 to 100 p.s.i.

Testing Methods*

To measure rinse line water pressure, the pressure gauge is installed between the pressure regulator and the final rinse valve of the dish machine. If a pressure regulator be not present, the gauge is installed between the rinse line shut-off valve and the dish machine rinse valve. At this location with the final rinse valve turned off, the static pressure is indicated. When the final rinse valve is turned on, the gauge indicates the flow pressure as the water moves through the pipe. In some instances, it is necessary to locate the gauge between the final rinse valve and the first rinse arm. At this location only flow pressure is determined.

To determine water temperature, the pyrometer wire leads are passed through a plastic plate from the back and looped through a wire fastener.

Time of the temperature rise and the maximum temperature indicated by the instruments are recorded.

The wash cycle efficiency is the most difficult single factor to determine with any accuracy. It is impossible to ascertain wash water volume and pressure by usual field testing methods without dismantling the pump and impeller system, but considerable information may be obtained by:

a. Determination of pump-packing leakage along shaft and in area of impeller packing nut. (A properly packed shaft will "weep" a little, especially for the first few minutes after the pump is started. A pump packed too tightly may "bind" and heat up bearings.)

b. Visual inspection of wash spray pattern inside machine.

c. Determination of any discernible noise indicating defective bearings, bent or misaligned shaft, or conspicuous over-heating of pump motor.

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*Evaluation of Mechanical Dishwashing Operations, F. H. Fiske, P. G. Stevenson, The Sanitarian Vol. 23, pp. 134-139, 1960-61.

The wash cycle efficiency is also dependent upon the adequate concentration of a suitable detergent. Numerous references in the literature place the proper concentration of alkalinity, expressed as sodium carbonate, at between 0.2% and 0.3%. (A test for alkalinity of the wash solution should be made.)

The testing methods of spray type dishwashing machines should incorporate the examination of the three basic features of machine dishwashing, as follows:

A. Mechanical condition of the dishwashing machine:
1. Temperature and flow pressure of the final rinse system
2. Temperature and detergent concentration of the wash water
3. Bacterial count determination on utensils by swab rinse methods
4. Visual examination of wash and rinse arms, jets and interior of the machine for excessive "liming", corrosion, and deterioration
5. Mechanical condition of conveyors, spray arms, wash arms and drainage systems
6. Visual examination of wash and rinse sprays, and pump and impeller units

B. Tentative sizing of hot water plants is done by using N.S.F. Standard No. 5. Machine consumption figures are taken from the N.S.F. approval list. Sizing is determined by the machine demand rated at 70% of the theoretical capacity plus additional general 140°F. water supply to all other fixtures calculated as follows:
1. Pot sinks - 15 gallons per hour per compartment
2. Hand bowls - 5 gallons per hour
3. Bar or fountain units - 5 gallons per hour per compartment
4. Pre-flush units - 45 gallons per hour
5. Hot tables, etc., calculated according to dimensions

C. Operational practices of personnel observed during inspections are recorded by category as follows:
1. Detergent application
2. Racking of utensils
3. Scraping and pre-flush
4. Handling and stacking after washing

Maintenance of Dishwashing Equipment: The following is a schedule for cleaning dishwashing equipment after each washing period:

a. Clean dish tables using detergent and rinse with fresh water. During this operation, scrap trays should remain in place in machine.
b. Turn off heat on wash and or rinse tanks.
c. Drain water from tanks and pumps.
d. Remove racks from door type machines, and curtains from curtain type machines.
e. Remove wash arms and/or end caps where arms are not removable and clean with brush provided for this purpose.
f. Check and clean, if necessary, final rinse sprays.
g. Remove and clean scrap trays.
h. Close tank drain; hose and scrub inside of machine thoroughly. Refill tank; flush out pump and pump lines by running the machine at least one minute; then drain tank.
i. Scrub and wash down curtains and hang in place for drying.
j. Replace scrap trays, wash arms and rinse arms.
k. Check machine for next operation, leaving all inspection doors open.
l. Clean and refill detergent dispenser.
m. Check filler opening, final rinse and pump packing glands for leakage.

Tests for Grading Utensil Cleanliness. The swab-rinse test should be recognized for what it is, i.e., a field test and not a laboratory procedure for precise measurements.

Where bacteriological laboratory facilities are available, the following swab test for determining the number of bacteria on utensil surfaces is recommended for the bacteriological examination of utensils which have been sanitized. The Standard Method for the Bacteriological Examination of Food Utensils proposed by the sub-committee on Food Utensil Sanitation of the American Public Health Association is used.

Collecting Samples. Utensils to be examined shall include at least glasses, cups, and spoons, if used, and at least 4 of each shall be selected at random from the shelves upon which clean utensils are stored. If a direct check of the dishwashing methods be desired, utensils should be selected from those recently washed. Care shall be taken to prevent contamination by handling during sampling.

Use 1 swab for each group of 4 or more similar utensils. Take the swab from a freshly-opened container of dilution water, or dip a sterile swab, if separate, in such dilution water, and squeese it against the side of the container so as to remove excess water, leaving the swab moist but not wet. Rub the swab slowly and firmly three times over the significant surfaces of 4 or more similar utensils, reversing the direction each time. After swabbing each utensil, return the swab to the container of dilution water, rotate the swab in the dilution water, and press out the excess water against the side of the container before swabbing the next of the 4 or more utensils in the group.

The significant surfaces of utensils consist of the upper one-half inch of the inner and outer rims of cups and glasses and the entire inner and outer surfaces of the bowls of spoons. If it be desired to examine forks and surfaces of dishes, etc., the area to be swabbed should include the entire inner and outer surfaces of the tines of forks, and the inner surfaces of plates and bowls over an area of 4 square inches that would come in contact with the food. On plates, swab 3 times, reversing the direction of each stroke completely across each of the two diameters at right angles to each other. On bowls, swab 3 times, reversing the direction of each stroke around the inner surface at a level at which the swab will hug the surface of the bowl about half way between the bottom of the bowl and the rim.

After completing the swabbing of all utensils in the group of 4 or more, replace the swab in the container of dilution water. If separate swabs be used, break off the swab in the container under aseptic conditions. Use a new swab container for the next group of utensils. Keep the containers iced while in transit to the laboratory and until samples are plated. Plate the dilution water samples as soon as possible, preferably within 4 hours of swabbing, but where this cannot be done, samples must be properly refrigerated and analyzed within 24 hours of swabbing.

Interpretation. The average plate count per utensil surface examined should not exceed 100. Higher counts are presumptive evidence of inadequate cleansing or bactericidal treatment or recontamination by handling or during storage.

Other Testing Methods. In Britain, the swabbing technique as a field control test has been found somewhat expensive and lacking in satisfactory on-the-spot educational value due to the fact that the results of the tests become available too long after inspection. In 1952, Brookes and Fennell described a powder-dusting technique for washed utensils in order to evaluate the effectiveness of dishwashing methods. This could be done on-the-spot, and immediately discussed with the operator and workers in the food establishment. The test appeared to correlate satisfactorily with the bacteriological swabbing test.

Agar Contact procedures of which there are a multitude of modifications, are all based on the same principle, i.e., nutrient agar is pressed against the surface of utensils to be examined and then removed and incubated in a petri dish.

Direct surface agar plating techniques, i.e., pouring melted agar directly on surface and then incubating it, have been developed in the past few years as refinements of the aforementioned procedures in an effort to achieve a truly quantitative measure of contamination. This method is too complicated for field use.

A direct surface replica technique developed by Masurovsky and Jordan is accomplished by painting clear fingernail polish over area to be examined, letting it dry, stripping it from surface, staining it, and examining it under microscope.[1] This is a time consuming method.

Radioisotope tagged bacteria have been used in laboratory research studies to try to demonstrate what techniques are necessary to obtain clean, contamination-free surfaces.

Horwood[2] has shown that utensils that have been thoroughly desoiled will become bacteria free to such a degree that sanitization by heat or chemicals is not required. These results emphasize the fact that the fundamental basis of sanitization is soil removal.

Recently, another powder-dusting technique has been proposed by Armbruster[3] as a screening test for the detection of grease, protein or starch films on multiple-use utensils. It consists of sprinkling a small amount of a mixture of Safranin-0 (15%) and talc (85%) on the utensil surface. This is followed by a thorough flushing of the surface with cold water until no more residual dye rinses off. All soiled areas, even thin films, will stain red. All unsoiled areas will not stain. Bacterial tests would be useful only after soil tests show up negative.] End of Insert

d. Storage and Handling of Cleaned Equipment and Utensils:

(1) Food-contact surfaces of cleaned and sanitized equipment and utensils shall be handled in such a manner so as to be protected from contamination. Cleaned spoons, knives, and forks shall be picked up and touched only by their handles. Clean cups, glasses, and bowls shall be handled so that fingers and thumbs do not contact inside surfaces or lip-contact surfaces.

(2) Cleaned, and cleaned and sanitized, portable equipment and utensils shall be stored above the floor in a clean, dry location, and suitable space and facilities shall be provided for such storage so that food-contact surfaces are protected from splash, dust, and other contamination. The food-contact surfaces of fixed equipment shall also be protected from splash, dust, and other contamination. Utensils shall be air dried before being stored, or shall be stored in a self-draining position on suitably located hooks or racks constructed of corrosion-resistant material. Wherever practicable, stored containers and utensils shall be covered or inverted. Facilities for the storage of flatware (silverware) shall be provided and shall be designed and maintained to present the handle to the employee or customer.

e. Single-Service Articles:

(1) Single-service articles shall be stored in closed cartons or containers which protect them from contamination.

(2) Such articles shall be handled and dispensed in such a manner as to prevent contamination of surfaces which may come into contact with food or with the mouth of the user.

(3) Single-service articles shall be used only once.

(4) All food-service establishments which do not have adequate and effective facilities for cleaning and sanitizing utensils shall use single-service articles.

Section E. Sanitary Facilities and Controls

1. Water Supply: The water supply shall be adequate, of a safe, sanitary quality, and from an approved source. Hot and cold running water, under pressure, shall be provided in all areas where food is prepared, or equipment, utensils, or containers are washed.

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1. Journal of Dairy Science, Vol. 43, pp. 1000-1003, 1960.
2. Sanitation, Vol. 9, pp. 193-196, 1947.
3. Sanitation, Vol. 23, pp. 103-104, 1960.
   Journal of American Dietetic Assn., Vol. 39, pp. 228-230, 1961.

Water, if not piped into the establishment, shall be transported and stored in approved containers, and shall be handled and dispensed in a sanitary manner.

Ice used for any purpose shall be made from water which comes from an approved source, and shall be used only if it has been manufactured, stored, transported, and handled in a sanitary manner.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. Supply:

(1) The water supply shall be adequate, of a safe, sanitary quality, and from an approved public or private water-supply system which is constructed, protected, operated, and maintained in conformance with applicable State and local laws, ordinances, and regulations: Provided, That, if approved by the health authority, a nonpotable water-supply system may be permitted within the establishment for purposes such as air conditioning and fire protection, only if such system complies fully with item 3.a. of this section, and the nonpotable water supply is not used in such a manner as to bring it into contact, either directly or indirectly, with food, food equipment, or utensils.

(2) Hot and cold running water, under pressure, shall be provided in all areas where food is prepared, and where equipment and utensils are washed.

b. Transporting and Dispensing Water:

(1) All water, not piped into the establishment directly from the source, shall be transported, handled, stored, and dispensed in a sanitary manner.

(2) Drinking water, if not dispensed through the water-supply system of the food-service establishment, may be stored in a separate nonpressurized tank, reservoir, or other container.

c. Ice:

(1) Ice shall be made from water meeting the requirements of paragraph a. (1) of this subsection, in an icemaking machine which is located, installed, operated, and maintained so as to prevent contamination of the ice; or shall be obtained from a source approved by the health authority.

(2) Ice shall be handled, transported, and stored in such a manner as to be protected against contamination. If block ice be used, the outer surfaces shall be thoroughly rinsed so as to remove any soil before it is used for any purpose.

(3) If ice crushers be used, they shall be maintained in a clean condition and shall be covered when not in use.

(4) If ice be used, approved containers and utensils shall be provided for storing and serving it in a sanitary manner. Ice buckets, other containers, and scoops, unless they be of the single-service type, shall be of a smooth, impervious material, and designed to facilitate cleaning. They shall be kept clean, and shall be stored and handled in a sanitary manner. Only sanitary containers shall be used for the transportation or storage of any ice used in the food-service establishment. Canvas containers shall not be used unless provided with a sanitary, single-service liner so as to completely protect the ice.

2. Sewage Disposal: All sewage shall be disposed of in a public sewerage system, or, in the absence thereof, in a manner approved by the health authority.

Reason: Improper disposal of sewage can result in conditions which may cause serious illness or disease outbreaks. Proper disposal is required to prevent contamination of ground

surfaces, possible pollution of water supplies, access by flies and other insects to human excreta, and the creation of other insanitary conditions. Improper disposal of sewage provides a potential for contamination of food, the food-contact surfaces of equipment and utensils, and private water-supply systems.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. Water-Carried Sewage:

(1) All water-carried sewage shall be disposed of by means of:

(a) A public sewerage systems; or
(b) An approved sewage disposal system which is constructed and operated in conformance with applicable State and local laws, ordinances, and regulations.

b. Non-Water-Carried Sewage:[12]

(1) Non-water-carried sewage-disposal facilities shall not be used, except where water-carried disposal methods have been determined by the health authority to be impractical. Under such conditions, only facilities which have been approved by the health authority shall be used, and operation of these facilities shall be in conformance with applicable State and local laws, ordinances, and regulations.

3. Plumbing: Plumbing shall be so sized, installed, and maintained as to carry adequate quantities of water to required locations throughout the establishment; as to prevent contamination of the water supply; as to properly convey sewage and liquid wastes from the establishment to the sewerage or sewage-disposal system; and so that it does not constitute a source of contamination of food, equipment, or utensils, or create an insanitary condition or nuisance.

Reason: If plumbing is improperly installed or maintained, a variety of public health hazards, such as cross-connections, backsiphonage, drainage system stoppage, or overhead leakage may occur. Any one of these conditions can result in serious contamination of the water supply, food, equipment, or utensils, or create nuisance or obnoxious odors. Also, reduced water pressures resulting from improperly sized and maintained pipelines may adversely affect the operation of dishwashing machines, food-water grinders, and similar items of equipment which depend upon sufficient pressure and volume to perform their intended functions. Thus, plumbing is a particularly important consideration in food-service establishments.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. General:

(1) All plumbing shall be sized, installed, and maintained in accordance with applicable State and local plumbing laws, ordinances, and regulations.

(2) The potable water-supply piping shall not be directly connected with any nonpotable water-supply system whereby the nonpotable water can be drawn or discharged into the potable water-supply system. The piping of any nonpotable water system shall be adequately and durably identified, such as by distinctive yellow-colored paint, so that it is readily distinguished from piping which carries potable water; and such piping shall not be connected to equipment or have outlets in the food-preparation area.

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12. Suggested standards and recommended practices are contained in Public Health Service Publication No. 24, revised 1962; also Chapter XV of this book.

(3) The potable water system shall be installed in such a manner so as to preclude the possibility of backsiphonage.

(4) Grease traps shall not be required, except in special cases as may be determined by the health authority.

b. Drains:

(1) Dishwashing machines, refrigerators, steam kettles, potato peelers, and similar types of enclosed equipment in which food, portable equipment, or utensils are placed, shall not be directly connected to the drainage system. Each waste pipe from such equipment shall discharge into an open, accessible, individual waste sink, floor drain, or other suitable fixture which is properly trapped and vented: Provided, That when a dishwashing machine is located adjacent to a floor drain, the waste from the dishwashing machine may be connected direct on the sewer side of the floor drain trap. Indirect connections of drain lines from other equipment used in the preparation of food or washing of equipment and utensils may be required by the health authority when, in his opinion, the installation is such that backflow of sewage is likely to occur. Each walk-in refrigerator shall be equipped with a floor drain, so installed as to preclude the backflow of sewage into the refrigerator; or all parts of the floor of each walk-in refrigerator shall be graded to drain to the outside through a wastepipe, doorway, or other opening.

(2) Indirect waste connections shall be provided for drains, over-flows, or relief vents from the water-supply system.

(3) Drain lines from equipment shall not discharge waste water in such a manner as will permit the flooding of floors or the flowing of water across working or walking areas, or into difficult-to-clean areas, or otherwise create a nuisance.

4. Toilet Facilities: Each food-service establishment shall be provided with adequate, conveniently located toilet facilities for its employees. Toilet fixtures shall be of sanitary design and readily cleanable. Toilet facilities, including rooms and fixtures, shall be kept in a clean condition and in good repair. The doors of all toilet rooms shall be self-closing. Toilet tissue shall be provided. Easily cleanable receptacles shall be provided for waste materials, and such receptacles in toilet rooms for women shall be covered. Where the use of non-water-carried sewage-disposal facilities have been approved by the health authority, such facilities shall be separate from the establishment. When toilet facilities are provided for patrons, such facilities shall meet the requirements of this subsection.

Reason: Adequate, sanitary toilet facilities are required to assure proper disposal of human excrements which carry pathogenic organisms. When toilet facilities are of a sanitary design and are kept clean and in good repair, and are properly used, the opportunities for the spread of contamination by flies, insects, clothing, hands, or other means are minimized. Receptacles are necessary for waste materials.

Where management provides employees with adequate toilet facilities which are kept clean and properly maintained, employees are more likely to have a proper attitude toward sanitary practices and conditions in the food-service establishment.

Non-water-carried sewage-disposal facilities require periodic cleaning, which is an insanitary operation. Furthermore, such facilities create insect, rodent, and odor control problems. Thus, non-water-carried sewage-disposal facilities should be kept separated from the food-service establishment.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. General:

(1) Toilet facilities shall be adequate and conveniently located, and shall be

accessible to the employees at all times.

(2) Toilet facilities shall be installed in accordance with applicable State and local laws, ordinances, and regulations, or in the absence thereof, approved by the health authority.

(3) Water closets and urinals shall be of a sanitary design.

(4) Toilet rooms shall be completely enclosed, and shall have tight-fitting, self-closing doors. Such doors shall not be left open except during cleaning or maintenance. If vestibules are provided, they shall be kept in a clean condition and in good repair.

b. Maintenance:

(1) Toilet facilities, including the toilet room and fixtures, shall be kept clean and in good repair, and free of objectionable odors.

(2) A supply of toilet tissue shall be provided at each toilet at all times. Easily cleanable receptacles shall be provided for waste materials, and such receptacles in toilet rooms for women shall be covered. Such receptacles shall be emptied at least once a day, and more frequently when necessary to prevent excessive accumulation of waste material.

5. Hand Washing Facilities: Each food-service establishment shall be provided with adequate, conveniently located hand-washing facilities for its employees, including a lavatory or lavatories equipped with hot and cold or tempered running water, hand-cleansing soap or detergent, and approved sanitary towels or other approved hand-drying devices. Such facilities shall be kept clean and in good repair.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. General:

(1) Lavatories shall be located within or immediately adjacent to all toilet rooms or vestibules. In all new establishments, and establishments which are extensively altered, lavatories shall also be located within the area where food is prepared.

(2) Lavatories shall be adequate in size and number and shall be so located as to permit convenient and expeditious use by all employees.

(3) Lavatories shall be installed in accordance with applicable State and local laws, ordinances, and regulations, or in the absence thereof, as approved by the health authority.

(4) Each lavatory shall be provided with hot and cold or tempered[13] running water. Where hot and cold running water is provided, a mixing valve or combination faucet is recommended and shall be required in new installations. Steam mixing valves are prohibited.

b. Maintenance:

(1) An adequate supply of hand-cleansing soap or detergent shall be available at each lavatory. An adequate supply of sanitary towels, or an approved hand-drying device, shall be available and conveniently located near the lavatory. Common towels are prohibited. When disposable towels are used, waste receptacles shall be located conveniently near the hand-washing facilities.

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13. Where tempered water is used, a temperature of 100°F. to 115°F. is recommended.

(2) Lavatories, soap dispensers, hand-drying devices, and all other components of the hand-washing facilities shall be kept clean and in good repair.

6. Garbage and Rubbish Disposal: All garbage and rubbish containing food wastes shall, prior to disposal, be kept in leakproof, non-absorbent containers which shall be kept covered with tight-fitting lids when filled or stored, or not in continuous use: Provided, That such containers need not be covered when stored in a special vermin-proofed room or enclosure, or in a food-waste refrigerator. All other rubbish shall be stored in containers, rooms, or areas in an approved manner. The rooms, enclosures, areas, and containers used shall be adequate for the storage of all food waste and rubbish accumulating on the premises. Adequate cleaning facilities shall be provided, and each container, room, or area shall be thoroughly cleaned after the emptying or removal of garbage and rubbish. Food-waste grinders, if used, shall be installed in compliance with State and local standards and shall be of suitable construction. All garbage and rubbish shall be disposed of with sufficient frequency and in such a manner as to prevent a nuisance.

Reason: Proper storage and disposal of garbage and rubbish is necessary to minimize the development of odors, to prevent such waste from becoming an attractant and harborage or breeding place for vermin, and to prevent the soiling of food-preparation and food-service areas. Improperly handled garbage creates nuisance conditions, makes housekeeping difficult, and may be a possible source of contamination of food equipment and utensils.

Food-waste grinders shall be suitably constructed, installed in accordance with approved plumbing practices, and properly operated in order to prevent the creation of insanitary conditions within the food establishment.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. Containers:

(1) All garbage and rubbish containing food waste shall be kept in containers, constructed of durable metal or other approved types of material, which do not leak and do not absorb liquids.

(2) All containers shall be provided with tight-fitting lids or covers and shall, unless kept in a special vermin-proofed room or enclosure or in a waste refrigerator, be kept covered when stored or not in continuous use.

(3) After being emptied, each container shall be thoroughly cleaned on the inside and outside in a manner so as not to contaminate food, equipment, utensils, or food-preparation areas. Brushes shall be provided for washing garbage containers and shall be used for no other purpose. Can-washing machines, steam-cleaning devices, or similar equipment should be used where the operation is large enough to warrant this type of equipment. Waste water from such cleaning operations shall be disposed of as sewage.

(4) There shall be a sufficient number of containers to hold all of the garbage and rubbish containing food waste which accumulates between periods of removal from the premises.

b. Storage:

(1) Garbage and rubbish containing food waste shall be stored so as to be inaccessible to vermin. All other rubbish shall be stored in a manner approved by the health authority.

(2) Storage facilities shall be adequate for the proper storage of all garbage and rubbish.

(3) Storage areas shall be clean, and shall not constitute a nuisance.

(4) Storage rooms or enclosures shall be constructed of easily cleanable,

washable materials and shall be vermin proofed. The floors, and the walls up to at least the level reached by splash or spray, shall be of relatively nonabsorbent materials. Garbage containers outside the establishment shall be stored either on a concrete slab, or on a rack which is at least 12 inches above the ground for a multiple bank of containers.

c. Food-Waste Grinders:

(1) Food-waste grinders shall be so constructed and installed as to comply with applicable State and local plumbing laws, ordinances, and regulations.

d. Disposal:

(1) All garbage and rubbish shall be disposed of daily, or at such other frequencies as may be approved by the health authority, and in such a manner as to prevent a nuisance.

(2) Where garbage or combustible rubbish is burned on the premises, an approved incinerator shall be provided, and shall be operated in such a manner as to comply with local regulations and so that it does not create a nuisance. Areas around such incinerators shall be kept in a clean and orderly condition.

7. Vermin Control: Effective measures shall be taken to protect against the entrance into the establishment and the breeding or presence on the premises of vermin.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. General:

(1) Effective control measures shall be utilized to minimize the presence of rodents, flies, roaches, and other vermin on the premises.

(2) The premises shall be kept in such condition as to prevent the harborage or feeding of vermin.

b. Screening:

(1) Unless flies and other flying insects are absent from the immediate vicinity of the establishment, all openings to the outer air shall be effectively protected against the entrance of such insects by self-closing doors, closed windows, screening, controlled air currents, or other effective means.

(2) Screening material shall be not less than 16-mesh to the inch or equivalent.

(3) Screen doors to the outer air shall be self-closing; and screens for windows, doors, skylights, transoms, and other openings to the outer air shall be tight-fitting and free of breaks.

c. Rodent Proofing:

(1) All openings to the outside shall be effectively protected against the entrance of rodents.[14]

Section F. Other Facilities and Operations

1. Floors, Walls, and Ceiling: The floor surfaces in kitchens, in all other rooms and areas in which food is stored or prepared and in which utensils are washed, and in walk-in refrigerators, dressing or locker rooms, and toilet rooms, shall be of smooth, nonabsorbent

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14. For rodent-proof construction methods see; "Rat-Borne Disease Prevention and Control" V. Rat-Proofing of Existing Buildings; VII. Rat-Proof Construction of New Buildings. Public Health Service Communicable Disease Center, Atlanta, Ga. (Also see chapter on Rodent Control in this Sanitarian's Handbook.)

materials, and so constructed as to be easily cleanable: Provided, That the floors of nonrefrigerated, dry-food-storage areas need not be nonabsorbent. All floors shall be kept clean and in good repair. Floor drains shall be provided in all rooms where floors are subjected to flooding-type cleaning or where normal operations release or discharge water or other liquid waste on the floor. All exterior areas where food is served shall be kept clean and properly drained, and surfaces in such areas shall be finished so as to facilitate maintenance and minimize dust.

The walls and ceilings of all rooms shall be kept clean and in good repair. All walls of rooms or areas in which food is prepared, or utensils or hands are washed, shall be easily cleanable, smooth, and light-colored, and shall have washable surfaces up to the highest level reached by splash or spray.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. Floors:

(1) All floors shall be kept clean and in good repair. Sawdust or wood shavings shall not be used on the floors.

(2) The floors of all food preparation, food storage, and utensil-washing rooms and areas, and walk-in refrigerators, dressing or locker rooms, and toilet rooms shall be constructed of smooth, durable, nonabsorbent, and easily cleanable materials such as concrete, terrazzo, ceramic tile, durable grades of linoleum or plastic, or tight wood impregnated with plastic: Provided, That in areas subject to spilling or dripping of grease or fatty substances, such floor coverings shall be of grease-resistant material; and Provided further, That floors of nonrefrigerated, dry-food-storage areas need not be nonabsorbent.

(3) Floor drains shall be provided in floors which are waterflushed for cleaning or which receive discharges of water or other fluid waste from equipment. Such floors shall be graded to drain.

(4) Carpeting may be used on the floors of interior dining areas. Such carpeting shall be in good repair and kept clean.

(5) The walking and driving surfaces of all exterior areas where food is served, such as drive-in restaurants, side-walk cafes, patio service, chuck-wagon service, and barbecues, shall be kept clean and free of debris, and shall be properly drained so that water will not accumulate. Such areas shall be surfaced with concrete or asphalt, or with gravel or similar material effectively treated to facilitate maintenance and to minimize dust.

(6) Mats or duckboards, if used, shall be so constructed as to facilitate being cleaned, and shall be kept clean. They shall be of such design and size as to permit easy removal for cleaning.

(7) All concrete, terrazzo, or ceramic tile floors, hereafter installed in food preparation, food storage, and utensil-washing rooms and areas, and in walk-in refrigerators, dressing or locker rooms, and toilet rooms, shall provide a coved juncture between the floor and wall. In all cases, the juncture between the floor and wall shall be closed.

b. Walls and Ceilings:

(1) All walls and ceilings, including doors, windows, skylights, and similar closures, shall be kept clean and in good repair.

(2) The walls of all food-preparation, utensil-washing, and hand-washing rooms or areas, shall have light-colored, smooth, easily cleanable surfaces, and such surfaces shall be washable up to at least the highest level reached by splash or spray. Acoustical materials may be used on the ceiling, provided ventilation is adequate to minimize grease and moisture absorption.

(3) Wall covering materials used, such as sheet metal, linoleum, plastic, paper, and similar materials, shall be so attached and sealed to the wall or ceiling as to leave no open spaces or cracks which would permit accumulation of grease or debris, or provide harborage for vermin.

(4) Studs, joists, and rafters shall not be left exposed in food preparation or utensil-washing areas or toilet rooms. If left exposed in other rooms, or areas, they shall be suitably finished and shall be kept clean and in good repair.

(5) Light fixtures, decorative material, and similar equipment and material attached to walls or ceilings, shall be kept clean.

2. Lighting: All areas in which food is prepared or stored or utensils are washed, hand-washing areas, dressing or locker rooms, toilet rooms, and garbage and rubbish storage areas shall be well lighted. During all clean-up activities, adequate light shall be provided in the area being cleaned, and upon or around equipment being cleaned.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. General:

(1) At least 20 foot-candles of light shall be required on all working surfaces and at least 10 foot-candles on all other surfaces and equipment, in food preparation, utensil-washing and hand-washing areas, and toilet rooms. Sources of artificial light shall be provided and used to the extent necessary to provide the required amounts of light on these surfaces when in use and when being cleaned. At least 5 foot-candles of light at a distance of 30 inches from the floor shall be required in all other areas, including dining areas during cleaning operations.

3. Ventilation: All rooms in which food is prepared or served or utensils are washed, dressing or locker rooms, toilet rooms, and garbage and rubbish storage areas shall be well ventilated. Ventilation hoods and devices shall be designed to prevent grease or condensate from dripping into food or onto food-preparation surfaces. Filters, where used, shall be readily removable for cleaning or replacement. Ventilation systems shall comply with applicable State and local fire prevention requirements and shall, when vented to the outside air, discharge in such manner as not to create a nuisance.

[Technical Aspects of Kitchen Ventilation *

Ventilation in its more complicated technical aspects is an engineer's job. Enough of information, however, is here presented to assist the sanitarian in appraising a faulty installation and give him a talking knowledge of the subject.

Hoods should be designed so that they will overhang the range on all sides. The recommended overhang is 0.4 of the distance between the bottom of the hood and the top of the range, but in no case should this be less than 12 inches. A minimum of 24 inches is recommended for the depth of the hood. The cooking operation should, if possible, be near the center of the hood, and the distance between hood and top of stove as short as conveniently possible.

Outlets from the hood should never be at the end of the hood. If a hood requires more than one outlet, these should be 6 feet apart and symmetrically placed, i.e., for a 12 foot hood, there should be 2 outlets, each one 3 feet from either end.

Generally, when one side of hood is against a wall, 100 cubic feet of air per minute per square foot of hood opening should be exhausted, and when hood is not against wall, the air exhausted should be 150 cubic feet per minute per square foot. In case of much deep fat frying or cross drafts, these figures should be increased considerably.

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*Insert

A velocity of about 2,000 feet per minute should be maintained in the duct leading from the hood. Round ducts are preferred.

Calculation: If the dimensions of a hood be 10 feet long and 4 feet wide with one side against the wall, then:

1. The amount of air to be exhausted would be 10 x 4 x 100 = 4,000 cubic ft. per minute.
2. The area of the duct opening would be $\frac{4000}{2000}$ = 2 square feet.
3. The diameter of the duct would be calculated by the formula:

Area = Radius ^{2} x 3.1416; therefore

2 square feet (288 sq. in.) = R^2 x 3.1416

$$R^2 = \frac{288}{3.1416} = 91.7$$

R = 9.57 inches

Diameter = 2 x 9.57 = 19.1 inches

In practice, an 18" duct would be used which give a velocity of about 2,200 feet per minute. If a rectangular duct were used, the size of the opening of the duct would be 1 foot by 2 feet.

Grease filters should be used in the hood to prevent the collecting of grease and other cooking by-products on the sides of the duct, on the exhaust fan blades, on building walls, etc. Most filter can be cleaned under a live steam jet, or stream of hot water, or swishing the filter in a solution of hot soapy water. Filters are made for low and high velocities.

V-belt driven propeller fans should never be used in conjunction with a duct system or on a range hood or where grease is encountered. The centrifugal or squirrel cage blower should be used.] (End of insert.)

Reason: Proper ventilation reduces condensation which may promote mold and bacterial growth, or which may drop into food or utensils, or on food-preparation surfaces. Proper ventilation also minimizes soiling of walls and ceilings, excessive heat, objectionable odors, and the concentration of toxic gases. It facilitates the removal from the establishment of air which becomes contaminated or odorous during cleaning operations or certain food-preparation activities, or from heating, cooking, and other types of equipment. Adequate ventilation of toilets and dressing rooms is necessary for similar reasons.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. General:

(1) All rooms shall be adequately ventilated, and ventilation facilities shall be maintained and operated so that all areas are kept reasonably free from excessive heat, steam, condensation, vapors, smoke, or fumes. Effective air-recovery systems may be used in the ventilation of these areas.

(2) All rooms, areas, and equipment, from which contaminated aerosols, obnoxious odors, or noxious fumes or vapors may originate, shall be effectively vented to the outside air.

(3) Ventilation hoods and devices shall be designed to prevent grease or condensate from dripping into food or onto food preparation surfaces. Filters, where used, shall be readily removable for cleaning and replacement.

(4) Where intake air ducts are used, they shall be designed and maintained so as to prevent the entrance of dust, dirt, insects, or other contaminating materials.

(5) Ventilation systems shall comply with applicable State and local fire-prevention requirements and when vented to the outside air, shall discharge in such manner as not to create a nuisance.

4. Dressing Rooms and Lockers: Adequate facilities shall be provided for the orderly storage of employees' clothing and personal belongings. Where employees routinely change clothes within the establishment, one or more dressing rooms or designated areas shall be provided for this purpose. Such designated areas shall be located outside of the food-preparation, storage, and serving areas, and the utensil-washing and storage areas: Provided, That, when approved by the health authority, such an area may be located in a storage room where only completely packaged food is stored. Designated areas shall be equipped with adequate lockers, and lockers or other suitable facilities shall be provided in dressing rooms. Dressing rooms and lockers shall be kept clean.

Reason: Street clothing and personal belongings can serve to contaminate food, food equipment, and food-preparation surfaces. To prevent this, adequate dressing rooms or areas, and lockers or other storage facilities, as well as special dress for food-service workers, are desirable. Clean and orderly dressing rooms or areas, and related facilities, contribute toward proper employee attitudes for neatness, orderliness, and cleanliness throughout the establishment.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. General:

(1) Adequate facilities shall be provided for the orderly storage of employees' clothing and personal belongings. Dressing rooms or designated areas shall be provided when, as a routine procedure, employees change clothing within the establishment. Such designated areas shall be located outside of food-preparation, storage, and serving areas, and utensil-washing and storage areas: Provided, That the health authority may approve such an area in a storage room where only completely packaged food is stored.

(2) Adequate lockers within dressing rooms or areas, or other suitable facilities within dressing rooms, shall be provided and used for the storage of employees' coats, clothing, and personal belongings.

(3) Dressing rooms or areas, and lockers, shall be kept in a clean condition.

5. Housekeeping: All parts of the establishment and its premises shall be kept neat, clean, and free of litter and rubbish. Cleaning operations shall be conducted in such a manner as to minimize contamination of food and food-contact surfaces. None of the operations connected with a food-service establishment shall be conducted in any room used as living or sleeping quarter. Soiled linens, coats, and aprons shall be kept in suitable containers until removed for laundering. No live birds or animals shall be allowed in any area used for the conduct of food-service establishment operations: Provided, That guide dogs accompanying blind persons may be permitted in dining areas.

Reason: Good housekeeping results in a clean and orderly environment. Proper storage helps to prevent errors in identification, such as the mistaken use of insecticides as food ingredients, and contributes to efficiency.

Care must be taken to prevent contaminating food or cleaned equipment during cleaning operations. For example, cleaning units which utilize high-velocity jets of hot water may be extremely effective, but improper use may scatter debris or create contaminating aerosols. Also, improper cleaning methods may raise dust which can settle on food and food-contact surfaces.

Storage rooms, loading docks, and the premises must be kept clean to minimize rodent and insect infestation, odors, dust, and other sources of nuisance or contamination.

The degree of protection required for commercial food-service operations is not routinely maintained in living and sleeping quarters. Live birds and animals may spread disease organisms, dust, and other contaminants.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. General:

(1) The establishment and all parts of the property used in connection with operation of the establishment shall be kept neat, clean, and free of litter and rubbish.

(2) None of the operations connected with the establishment shall be conducted in any room used as living or sleeping quarters.

b. Dustless Cleaning:

(1) Vacuum cleaning, wet cleaning, or other dustless methods of floor and wall cleaning shall be used; or dust-arresting sweeping compounds and pushbrooms shall be employed; and all such cleaning, except emergency floor cleaning, shall be done during those periods when the least amount of food is exposed, such as after closing or between meals.

c. Storage of Linens and Clothes:

(1) Laundered cloths and napkins shall be stored in a clean place until used.

(2) Nonabsorbent containers or laundry bags shall be provided, and damp or soiled linens and clothes shall be kept therein until removed for laundering.

d. Live Birds and Animals:

(1) No live birds or animals shall be allowed in any area used for the storage, preparation, or serving of food, or for the cleaning or storage of utensils, or in toilet rooms, employees' dressing rooms or areas, in vehicles used for transporting food, or in any other area or facility used in the conduct of food-service establishment operations: Provided, That guide dogs accompanying blind persons may be permitted in dining areas.

Section G. Temporary Food Service Establishments

A temporary food-service establishment shall comply with all provisions of this ordinance which are applicable to its operation: Provided, That the health authority may augment such requirements when needed to assure the service of safe food; may prohibit the sale of certain potentially hazardous food; and may modify specific requirements for physical facilities when in his opinion no imminent health hazard will result.

Reason: Due to the nature, location, and variety of conditions surrounding the operation of temporary food-service establishments, at fairs, carnivals, and other transitory gatherings, it is frequently infeasible to provide certain physical facilities required for "permanent" establishments. In order to assure adequate protection of food served by temporary establishments which are unable to meet fully the requirements of this ordinance, it may be necessary to restrict the types of food sold or the methods by which served, to modify some requirements for procedures and facilities, and to impose additional requirements.

Compliance: This subsection shall be deemed to have been satisfied when the following requirements are met:

a. Unrestricted Establishments:

(1) For unrestricted food-service operations, a temporary food-service establishment shall meet fully the requirements of this ordinance, as set forth in sections B. through F., which are applicable to its operations.

b. Restricted Establishments:

(1) When, in the opinion of the health authority, no imminent hazard to the public health will result, temporary food-service establishments, which do not fully meet the requirements of sections B. through F. of this ordinance, may be permitted to operate when food preparation and service are restricted and deviations from full compliance are covered by the additional or modified requirements, as set forth below:

a. The preparation of potentially hazardous food, such as cream-filled pastries, custards, and similar products, and meat, poultry, and fish in the form of salads or sandwiches, shall be prohibited: Provided, That this prohibition shall not apply to hamburgers, frankfurters, and other food which, prior to service, requires only limited preparation, such as seasoning and cooking: and Provided further, That this prohibition shall not apply to any potentially hazardous food which is obtained in individual servings, is stored in approved facilities which maintain such food at safe temperatures, and is served directly in the individual, original container in which it was packaged at a commercial food establishment.

b. Ice which will be consumed, or which will come into contact with food, shall be obtained from an approved source in chipped, crushed, or cubed form. Such ice shall be obtained in single-service, closed containers of an approved type, and shall be held therein until used.

c. Wet storage of packaged food and beverage shall be prohibited: Provided, That wet storage of pressurized containers of beverages may be permitted when: (1) the water contains at least 50 ppm. of available chlorine; and (2) the iced water is changed frequently enough to keep both the water and container clean.

d. Food-contact surfaces of food-preparation equipment such as grills, stoves, and worktables shall be protected from contamination by customers and dust. Where necessary, effective shields shall be provided.

e. Equipment shall be installed in such a manner that the establishment can be kept clean, and so that food will not become contaminated.

f. An adequate supply of water for cleaning and hand-washing shall be maintained in the establishment, and auxiliary heating facilities, capable of producing an ample supply of hot water for such purposes, shall be provided.

g. Liquid waste which is not discharged into a sewerage system shall be disposed of in such a manner as not to create a public health hazard or nuisance condition.

h. Adequate facilities shall be provided for employee hand washing. Such facilities may consist of a pan, water, soap, and individual paper towels.

i. Floors shall be of tight wood, asphalt, or other cleanable material: Provided, That the health authority may accept dirt-or gravel-covered floors when graded to preclude the accumulation of liquids and covered with removable, cleanable, wooden platforms or duckboards.

j. Walls and ceilings shall be so constructed as to minimize the entrance of flies and dust. Temporary construction may be accepted. Ceilings may be of wood, canvas, or other materials which protect the interior of the establishment from the elements, and walls may be of such materials or of 16-mesh screening or equivalent. When flies are prevalent, counter service openings shall either be equipped with self-closing, fly-tight doors, or the opening protected by effective fans. Where fans are used for this purpose, the size of the opening shall be so limited that the fans employed will effectively prevent the entrance of flies.

k. Any other requirement deemed necessary by the health authority to protect the public health in view of the particular nature of the food-service operation shall be met.

Section H. Enforcement Provisions

1. Permits: It shall be unlawful for any person to operate a food-service establishment within the municipality[15] of _____, or its police jurisdiction, who does not possess a valid permit issued to him by the health authority. Only a person who complies with the requirements of this ordinance shall be entitled to receive and retain such a permit. Permits shall not be transferable from one person to another person or place. A valid permit shall be posted in every food-service establishment. Permits for temporary food-service establishments shall be issued for a period of time not to exceed 14 days.

a. Issuance of Permits: Any person desiring to operate a food-service establishment shall make written application for a permit on forms provided by the health authority. Such application shall include: the applicant's full name and post office address and whether such applicant is an individual, firm, or corporation, and, if a partnership, the names of the partners, together with their addresses shall be included; the location and type of the proposed food-service establishment; and the signature of the applicant or applicants. If the application is for a temporary food-service establishment, it shall also include the inclusive dates of the proposed operation.

Upon receipt of such an application, the health authority shall make an inspection of the food-service establishment to determine compliance with the provisions of this ordinance. When inspection reveals that the applicable requirements of this ordinance have been met, a permit shall be issued to the applicant by the health authority.

b. Suspension of Permits: Permits may be suspended temporarily by the health authority for failure of the holder to comply with the requirements of this ordinance.

Whenever a permit holder or operator has failed to comply with any notice issued under the provisions of section H. of this ordinance, the permit holder or operator shall be notified in writing that the permit is, upon service of the notice, immediately suspended (or the establishment downgraded),[16] and that an opportunity for a hearing will be provided if a written request for a hearing be filed with the health authority by the permit holder.

Notwithstanding the other provisions of this ordinance, whenever the health authority finds insanitary or other conditions in the operation of a food-service establishment which, in his judgment, constitute a substantial hazard to the public health, he may without warning, notice, or hearing, issue a written notice to the permit holder or operator citing such condition, specifying the corrective action to be taken, and specifying the time period within which such action shall be taken; and if deemed necessary, such order shall state that the permit be immediately suspended, and all food-service operations are to be immediately discontinued. Any person to whom such an order is issued shall comply immediately therewith, but upon written petition to the health authority, shall be afforded a hearing as soon as possible.

c. Reinstatement of Suspended Permits: Any person whose permit has been suspended may, at any time, make application for a reinspection for the purpose of reinstatement of this permit. Within 10 days following receipt of a written request, including a statement signed by the applicant that in his opinion the conditions causing suspension of the permit have been corrected, the health authority shall make a reinspection. If the applicant be complying with the requirements of this ordinance, the permit shall be reinstated.

d. Revocation of Permits: For serious or repeated violations of any of the requirements of this ordinance, or for interference with the health authority in the performance of his duties, the permit may be permanently revoked after an opportunity for a hearing has been provided by the health authority. Prior to such action, the health authority shall notify the permit holder in writing, stating the reasons for which the permit is subject to revocation and advising

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15. See footnote 2.
16. See Footnote 1.

that the permit shall be permanently revoked at the end of 5 days following service of such notice, unless a request for a hearing be filed with the health authority, by the permit holder, within such 5-day period. A permit may be suspended for cause pending its revocation or a hearing relative thereto.

e. Hearings: The hearings provided for in this section shall be conducted by the health authority at a time and place designated by him. Based upon the record of such hearing, the health authority shall make a finding and shall sustain, modfy, or rescind any official notice or order considered in the hearing. A written report of the hearing decision shall be furnished to the permit holder by the health authority.

2. Inspection of Food Service Establishments: At least once every 6 months, the health authority shall inspect each food-service establishment located in the municipality[17] of _____, or its police jurisdiction, and shall make as many additional inspections and reinspections as are necessary for the enforcement of this ordinance.

a. Access to Establishments: The health authority, after proper identification, shall be permitted to enter, at any reasonable time, any food-service establishment within the municipality[18] of _____, or its police jurisdiction, for the purpose of making inspections to determine compliance with this ordinance. He shall be permitted to examine the records of the establishment to obtain pertinent information pertaining to food and supplies purchased, received or used, and persons employed.

b. Inspection Records; Dermerit Values; Demerit Scores: Whenever the health authority makes an inspection of a food-service establishment, he shall record his findings on an inspection report form provided for this purpose, and shall furnish the original of such inspection report form to the permit holder or operator. Such form shall summarize the requirements of sections B. through G. of this ordinance and shall set forth demerit point values for each such requirement, in accordance with PHS Form 4006, a copy of which is appended as a part of this section. Upon completion of an inspection, the health authority shall total the demerit point values for all requirements in violation, such total becoming the demerit score for the establishment.

c. Issuance of Notices: Whenever the health authority makes an inspection of a food-service establishment and discovers that any of the requirements of sections B. through G. of this ordinance have been violated, he shall notify the permit holder or operator of such violations by means of an inspection report form or other written notice. In such notification, the health authority shall:

(1) Set forth the specific violations found, together with the demerit score of the establishment.

(2) Establish a specific and reasonable period of time for the correction of the violations found, in accordance with the following provisions:

(a) When the demerit score of the establishment is 20 or less, all violations of 2 or 4 demerit points must be corrected by the time of the next routine inspection; or

(b) When the demerit score of the establishment is more than 20 but not more than 40, all items of 2 or 4 demerit points must be corrected within a period of time not to exceed 30 days; or

(c) When one or more 6 demerit point items are in violation, regardless of demerit score, such items must be corrected within a period of time not to exceed 10 days.

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17. See footnote 2.
18. See footnote 2.

PHS-4006
4-62

INSPECTION REPORT
FOOD SERVICE ESTABLISHMENTS

Permit No. _____
Type _____ NSD _____

CITY, COUNTY OR DISTRICT	NAME OF ESTABLISHMENT	ADDRESS	OWNER OR OPERATOR

Sir: Based on an inspection this day, the items marked below identify the violation in operation or facilities which must be corrected by the next routine inspection or such shorter period of time as may be specified in writing by the health authority. Failure to comply with this notice may result in immediate suspension of your permit (or downgrading of the establishment).* An opportunity for an appeal will be provided if a written request for a hearing is filed with the health authority within the period of time established in this notice for the correction of violations.

Item	SECTION B. FOOD 1. FOOD SUPPLIES	Specify:	Bakery products	Poultry and poultry products	Meat and meat products	Frozen desserts	Shellfish	Milk and milk products	Demerit points
1	Approved source								6
2	Wholesome - not adulterated								6
3	Not misbranded								2
4	Original container; properly identified								2
5	Approved dispenser								
6	Fluid milk and fluid milk products pasteurized								6
7	Low-acid and non-acid foods commercially canned								6

Item	2. FOOD PROTECTION	Preparation	Storage	Display	Service	Transportation	Demerit points
8	Protected from contamination						4
9	Adequate facilities for maintaining food at hot or cold temperatures						2
10	Suitable thermometers properly located						2
11	Perishable food at proper temperature						2
12	Potentially hazardous food at 45° F. or below, or 140° F. or above as required						6
13	Frozen food kept frozen; properly thawed						2
14	Handling of food minimized by use of suitable utensils						4
15	Hollandaise sauce of fresh ingredients; discarded after three hours						6
16	Food cooked to proper temperature						6
17	Fruits and vegetables washed thoroughly						2
18	Containers of food stored off floor on clean surfaces						2
19	No wet storage of packaged food						2
20	Display cases, counter protector devices or cabinets of approved type						2
21	Frozen dessert dippers properly stored						2
22	Sugar in closed dispensers or individual packages						2
23	Unwrapped and potentially hazardous food not re-served						4
24	Poisonous and toxic materials properly identified, colored, stored and used; poisonous polishes not present						6
25	Bactericides, cleaning and other compounds properly stored and non-toxic in use dilutions						

Item	SECTION C. PERSONNEL 1. HEALTH AND DISEASE CONTROL	Demerit points
26	Persons with boils, infected wounds, respiratory infections or other communicable disease properly restricted	6
27	Known or suspected communicable disease cases reported to health authority	6

Item	2. CLEANLINESS	Demerit points
28	Hands washed and clean	6
29	Clean outer garments; proper hair restraints used	2
30	Good hygienic practices	4

Item	SECTION D. FOOD EQUIPMENT AND UTENSILS 1. SANITARY DESIGN, CONSTRUCTION AND INSTALLATION OF EQUIPMENT AND UTENSILS	Good repair; no cracks	No chips, pits or open seams	Cleanable; smooth	Approved material	No corrosion	Proper construction	Accessible for cleaning and inspection	Demerit points
31	Food-contact surfaces of equipment								2
32	Utensils								2
33	Non-food-contact surfaces of equipment								2
34	Single-service articles of non-toxic materials								2
35	Equipment properly installed								2
36	Existing equipment capable of being cleaned, non-toxic, properly installed, and in good repair								2

Item	2. CLEANLINESS OF EQUIPMENT AND UTENSILS	Demerit points
37	Tableware clean to sight and touch	
38	Kitchenware and food-contact surfaces of equipment clean to sight and touch	4
39	Grills and similar cooking devices cleaned daily	
40	Non-food-contact surfaces of equipment kept clean	2
41	Detergents and abrasives rinsed off food-contact surfaces	2
42	Clean wiping cloths used; use properly restricted	2
43	Utensils and equipment pre-flushed, scraped or soaked	2
44	Tableware sanitized	
45	Kitchenware and food-contact surfaces of equipment used for potentially hazardous food sanitized	4
46	Facilities for washing and sanitizing equipment and utensils approved, adequate, properly constructed, maintained and operated	4
47	Wash and sanitizing water clean	
48	Wash water at proper temperature	2
49	Dish tables and drain boards provided, properly located and constructed	2
50	Adequate and suitable detergents used	2
51	Approved thermometers provided and used	
52	Suitable dish baskets provided	2
53	Proper gauge cocks provided	
54	Cleaned and cleaned and sanitized utensils and equipment properly stored and handled; utensils air-dried	2
55	Suitable facilities and areas provided for storing utensils and equipment	2
56	Single-service articles properly stored, dispensed and handled	2
57	Single-service articles used only once	
58	Single-service articles used when approved washing and sanitizing facilities are not provided	6

Item	SECTION E. SANITARY FACILITIES AND CONTROLS 1. WATER SUPPLY	Demerit points
59	From approved source; adequate; safe quality	6
60	Hot and cold running water provided	4
61	Transported water handled, stored; dispensed in a sanitary manner	6
62	Ice from approved source; made from potable water	6
63	Ice machines and facilities properly located, installed and maintained	2
64	Ice and ice handling utensils properly handled and stored; block ice rinsed	2
65	Ice-contact surfaces approved; proper material and construction	

*Applicable only where grading form of ordinance is in effect.

Figure 3

Item	2. SEWAGE DISPOSAL	Demerit Points
66	Into public sewer, or approved private facilities	6
	3. PLUMBING	
67	Properly sized, installed and maintained	2
68	Non-potable water piping identified	1
69	No cross connections	6
70	No back siphonage possible	
71	Equipment properly drained	2
	4. TOILET FACILITIES	
72	Adequate, conveniently located, and accessible; properly designed and installed	6
73.	Toilet rooms completely enclosed, and equipped with self-closing, tight-fitting doors; doors kept closed	2
74	Toilet rooms, fixtures and vestibules kept clean, in good repair, and free from odors	2
75	Toilet tissue and proper waste receptacles provided; waste receptacles emptied as necessary	2
	5. HAND-WASHING FACILITIES	
76	Lavatories provided, adequate, properly located and installed	6
77	Provided with hot and cold or tempered running water through proper fixtures	4
78	Suitable hand cleanser and sanitary towels or approved hand-drying devices provided	2
79	Waste receptacles provided for disposable towels	2
80	Lavatory facilities clean and in good repair	2
	6. GARBAGE AND RUBBISH DISPOSAL	
81	Stored in approved containers; adequate in number	2
82	Containers cleaned when empty; brushes provided	2
83	When not in continuous use, covered with tight fitting lids, or in protective storage inaccessible to vermin	2
84	Storage areas adequate; clean; no nuisances; proper facilities provided	2
85	Disposed of in an approved manner, at an approved frequency	2
86	Garbage rooms or enclosures properly constructed; outside storage at proper height above ground or on concrete slab	2
87	Food waste grinders and incinerators properly installed, constructed and operated; incinerators areas clean	2
	7. VERMIN CONTROL	
88	Presence of rodents, flies, roaches and vermin minimized	4
89	Outer openings protected against flying insects as required; rodent-proofed	2
90	Harborage and feeding of vermin prevented	2

Item	SECTION F. OTHER FACILITIES 1. FLOORS, WALLS AND CEILINGS	Demerit Points
91	Floors kept clean; no sawdust used	2
92	Floors easily cleanable construction, in good repair, smooth, non-absorbent; carpeting in good repair	1
93	Floor graded and floor drains, as required	2
94	Exterior walking and driving surfaces clean; drained	2
95	Exterior walking and driving surfaces properly surfaced	1
96	Mats and duck boards cleanable, removable and clean	2
97	Floors and wall junctures properly constructed	2
98	Walls, ceilings and attached equipment clean	2
99	Walls and ceilings properly constructed and in good repair; coverings properly attached	1
100	Walls of light color; washable to level of splash	2
	2. LIGHTING	
101	20 foot-candles of light on working surfaces	2
102	10 foot-candles of light on food equipment, utensil-washing, hand-washing areas and toilet rooms	
103	5 foot-candles of light 30" from floor in all other areas	
104	Artificial light sources as required	2
	3. VENTILATION	
105	Rooms reasonably free from steam, condensation, smoke, etc.	2
106	Rooms and equipment vented to outside as required	2
107	Hoods properly designed; filters removable	2
108	Intake air ducts properly designed and maintained	1
109	Systems comply with fire prevention requirements; no nuisance created	2
	4. DRESSING ROOMS AND LOCKERS	
110	Dressing rooms or areas as required; properly located	1
111	Adequate lockers or other suitable facilities	1
112	Dressing rooms, areas and lockers kept clean	2
	5. HOUSEKEEPING	
113	Establishment and property clean, and free of litter	2
114	No operations in living or sleeping quarters	2
115	Floors and walls cleaned after closing or between meals by dustless methods	2
116	Laundered clothes and napkins stored in clean place	2
117	Soiled linen and clothing stored in proper containers	1
118	No live birds or animals other than guide dogs	2

DEMERIT SCORE OF THE ESTABLISHMENT _____

REMARKS _____

Date _____ Health Authority _____

Figure 3

(d) When the demerit score of the establishment is more than 40, the permit is immediately suspended.

(e) In the case of temporary food-service establishments, violations must be corrected within a specified period of time not to exceed 24 hours. Failure to comply with such notice shall result in immediate suspension of the permit.

(3) State that failure to comply with any notice issued in accordance with the provisions of this ordinance may result in immediate suspension of the permit (or the establishment downgraded).[19]

(4) State that an opportunity for appeal from any notice or inspection findings will be provided if a written request for a hearing be filed with the health authority within the period of time established in the notice for correction.

d. Service of Notices: Notices provided for under this section shall be deemed to have been properly served when the original of the inspection report form or other notice has been delivered personally to the permit holder or person in charge, or such notice has been sent by registered or certified mail, return receipt requested, to the last-known address of the permit holder. A copy of such notice shall be filed with the records of the health authority.

(e. Grading of Food Service Establishments: Every food-service establishment in the municipality[20] of _____, or its police jurisdiction, shall display, in a place designated by the health authority, a placard approved by the health authority stating the grade received at the time of the most recent inspection of the establishment: Provided, That temporary food-service establishments shall not be subject to grading.

Grades of establishments shall be as follows:
Grade A. An establishment having a demerit score of not more than 10.
Grade B. An establishment having a demerit score of more than 10 but not more than 20.
Grade C. An establishment having a demerit score of more than 20 but not more than 40.

Notwithstanding the grade criteria established above, whenever a second consecutive violation of any item of 2 or 4 demerit points is discovered, the permit may be suspended (H.1.b.) or in lieu thereof, the establishment shall be downgraded to the next lower grade.

Immediately following each inspection, the health authority shall post the appropriate grade based upon the inspection findings, and shall issue an appropriate notice in accordance with subsection H.2.c. of this ordinance.

The permit holder or operator of any establishment, the grade of which has been lowered, may at any time request an inspection for the purpose of regrading the establishment. Within 10 days following receipt of a request including a signed statement that the conditions responsible for the lowering of the grade have, in the applicant's opinion, been corrected, the health authority shall make an inspection, and thereafter as many additional inspections as he may deem necessary to assure himself that the applicant is complying with the higher grade requirements; and, if the findings indicate compliance, shall award the higher grade.)[21]

3. Examination and Condemnation of Food: Food may be examined or sampled by the health authority as often as may be necessary to determine freedom from adulteration or misbranding. The health authority may, upon written notice to the owner or person in charge, place a hold order on any food which he determines or has probable cause to believe to be

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19. See Footnote 1.
20. See footnote 2.
21. See Footnote 1.

unwholesome or otherwise adulterated, or misbranded. Under a hold order, food shall be permitted to be suitably stored. It shall be unlawful for any person to remove or alter a hold order, notice, or tag placed on food by the health authority, and neither such food nor the containers thereof shall be relabeled, repacked, reprocessed, altered, disposed of, or destroyed without permission of the health authority, except on order by a court of competent jurisdiction. After the owner or person in charge has had a hearing as provided for in subsection H. 2. c. (4), and on the basis of evidence produced at such hearing, or on the basis of his examination in the event a written request for a hearing is not received within 10 days, the health authority may vacate the hold order, or may by written order direct the owner or person in charge of the food which was placed under the hold order to denature or destroy such food or to bring it into compliance with the provisions of this ordinance: Provided, That such order of the health authority to denature or destroy such food or bring it into compliance with the provisions of this ordinance shall be stayed if the order be appealed to a court of competent jurisdiction within 3 days.

Discussion: This section authorizes the health authority to examine, hold, and condemn food which is unwholesome or otherwise adulterated, or misbranded. The local health authority may find it more practicable to limit condemnations to spoiled foods, those suspected of having caused or being able to cause food-borne illness or other conditions which may involve an immediate health hazard; and to refer those cases of suspected adulteration and misbranding which involve no immediate health hazard to State food-control officials.

Samples for the determination of adulteration and misbranding should be taken and examined in accordance with the methods prescribed by the Association of Official Agricultural Chemists, the Meat Inspection Branch of the U. S. Department of Agriculture, the Food and Drug Administration, or by other standard methods.

When cases of foodborne illness are reported, an immediate epidemiological and laboratory investigation should be made by the official agency in an effort to determine the vehicle and the source, so as to prevent a recurrence. Any food suspected of being a vehicle in a foodborne-disease outbreak should be placed under a hold order pending laboratory examination.

4. Food-Service Establishments Outside Jurisdiction of the Health Authority: Food from food-service establishments outside the jurisdiction of the health authority of the municipality[22] of _____ may be sold within the municipality[22] of _____ if such food-service establishments conform to the provisions of this ordinance or to substantially equivalent provisions. To determine the extent of compliance with such provisions, the health authority may accept reports from responsible authorities in other jurisdictions where such food-service establishments are located.

Discussion: The health authority should permit the sale within his jurisdiction of food received from any food-service establishment not under his routine inspection if the establishment (1) operates under regulations substantially equivalent to those of this ordinance; (2) be under routine official supervision; and (3) be located in a community which has been awarded by the food-service establishment sanitation authority, of the State, a sanitation rating equal to that of the receiving community, on the basis of the Public Health Service rating method.

5. Plan Review of Future Construction: When a food-service establishment is hereafter constructed or extensively remodeled, or when an existing structure is converted for use as a food-service establishment, properly prepared plans and specifications for such construction, remodeling, or alteration, showing layout, arrangement, and construction materials of work areas, and the location, size, and type of fixed equipment and facilities, shall be submitted to the health authority for approval before such work is begun.

Discussion: The purpose in requiring that properly prepared plans for all new construction and reconstruction be submitted for approval before such work is begun is: (1) to insure compliance with sanitary requirements; (2) to prevent any misunderstanding by the operator as

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22. See footnote 2.

to what is required; and (3) to prevent errors which might later result in additional cost to the operator.

6. Procedure When Infection is Suspected: When the health authority has reasonable cause to suspect possibility of disease transmission from any food-service establishment employee, the health authority shall secure a morbidity history of the suspected employee, or make such other investigation as may be indicated, and take appropriate action. The health authority may require any or all of the following measures: (a) the immediate exclusion of the employee from all food-service establishments; (b) the immediate closure of the food-service establishment concerned until, in the opinion of the health authority, no further danger of disease outbreak exists; (c) restriction of the employee's services to some area of the establishment where there would be no danger of transmitting disease; and (d) adequate medical and laboratory examinations of the employee, of other employees, and of his and their body discharges.

Discussion: Preemployment and periodic medical examinations of food-service establishment employees are not required by this ordinance because such examinations do not provide protection against illness which might be transmitted by food.

Examinations and test for tuberculosis or venereal diseases should not be regarded as a part of a food-protection program, but rather as a part of the community's tuberculosis or venereal disease control program.

7. Penalties: Any person who shall violate any of the provisions of this ordinance shall be guilty of a misdemeanor and, upon conviction thereof, shall be punished by a fine of not more than _____. In addition thereto, such persons may be enjoined from continuing such violation. Each day upon which such a violation occurs shall constitute a separate violation.[23]

8. Repeal and Date of Effect: This ordinance shall be in full force and effect 12 months after its adoption and publication as provided by law; and, at that time, all ordinances and parts of ordinances in conflict with this ordinance are hereby repealed.

9. Unconstitutionality Clause: Should any section, paragraph, sentence, clause, or phrase of this ordinance be declared unconstitutional or invalid for any reason, the remainder of said ordinance shall not be affected thereby.

Sanitation Ordinance and Code Covering the Vending of Food and Beverages 1965 Recommendations

A sanitation ordinance regulating the sale of food and beverages through vending machines; defining vending machine, operator, health authority, and other terms; requiring permits for the installation and operation of vending machines; prohibiting the sale of, or possession with intent to sell through vending machines, adulterated or misbranded food or drink; regulating maintenance and operation of vending machines; authorizing official inspection of vending machines and operations connected therewith; and providing for the enforcement of this ordinance and the fixing of penalties.

Be it ordained by the _____ of the municipality[24] of _____ _____ as follows:

23. This provision must be worded in accordance with community laws and the State Constitution. Where legally possible, the desirability is suggested of prescribing a minimum fine, and an increased fine for second and subsequent offenses.

24. Substitute proper legal jurisdiction here and in all similar places throughout the ordinance.

Section I. Definitions

The following definitions shall apply in the interpretation and the enforcement of this ordinance:

1. Adulterated shall mean the condition of a food (a) if it bears or contains any poisonous or deleterious substance in a quantity which may render it injurious to health; (b) if it bears or contains any added poisonous or deleterious substance for which no safe tolerance has been established by regulation, or in excess of such tolerance if one has been established; (c) if it consists in whole or in part of any filthy, putrid, or decomposed substance, or if it be otherwise unfit for human consumption; (d) if it has been processed, prepared, packed, or held under insanitary conditions, whereby it may have become contaminated with filth, or whereby it may have been rendered injurious to health; (e) if it be in whole or in part of any poisonous or deleterious substance which may render the contents injurious to health.

2. Approved shall mean acceptable to the health authority based on his determination as to conformance with appropriate standards and good public health practice.

3. Closed shall mean fitted together snugly leaving no openings large enough to permit the entrance of vermin.

4. Commissary shall mean catering establishment, restaurant, or any other place in which food, containers or supplies are kept, handled, prepared, packaged, or stored, and directly from which vending machines are serviced.

5. Corrosion-Resistant Material shall mean a material which maintains its original surface characteristics under prolonged influence of the food, cleaning compounds, and sanitizing solutions which may contact it.

6. Easily Cleanable shall mean readily accessible and of such material and finish, and so fabricated that residue may be completely removed by normal cleaning methods.

7. Employee shall mean any operator or any person employed by him who handles any food to be dispensed through vending machines, or who comes into contact with food-contact surfaces of containers, equipment, utensils, or packaging materials, used in connection with vending machine operations, or who otherwise services or maintains one or more such machines.

8. Food shall mean any raw, cooked, or processed edible substance, beverage, or ingredient used or intended for use or for sale in whole or in part for human consumption.

9. Food-Contact Surfaces shall mean those surfaces of equipment and utensils with which food normally comes in direct contact, and those surfaces with which food may come in contact and drain back onto surfaces normally in contact with food.

10. Health Authority shall mean the health authority of the municipality[25] of _____ or his designated representative.

11. Machine Location shall mean the room, enclosure, space, or area where one or more vending machines are installed and opened.

12. Misbranded shall mean the presence of any written, printed, or graphic matter, upon or accompanying food or containers of food, including signs or placards displayed in relation to such products, which is false or misleading, or which violates any applicable State or local labeling requirements.

13. Operator shall mean any person, who by contract, agreement, or ownership, takes responsibility for furnishing, installing, servicing, operating, or maintaining one or more

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25. See footnote 1.

vending machines.

14. Perishable Food shall mean any food of such type or in such condition as may spoil.

15. Person shall mean an individual, or a firm, partnership, company, corporation, trustee, association, or any public or private entity.

16. Potentially Hazardous Food shall mean any perishable food which consists in whole or in part of milk or milk products, eggs, meat, poultry, fish, shellfish, or other ingredients capable of supporting rapid and progressive growth of infectious or toxigenic micro-organisms.[26]

17. Safe Temperature as applied to potentially hazardous food, shall mean temperatures of 45°F. or below, or 140°F. or above.

18. Sanitize shall mean effective bactericidal treatment of clean surfaces of equipment and utensils by a process which has been approved by the health authority as being effective in destroying micro-organisms, including pathogens.

19. Single Service Articles shall mean cups, containers, lids or closures, plates, knives, forks, spoons, stirrers, paddles; straws, place mats, napkins, doilies, wrapping materials; and all similar articles which are constructed wholly or in part from paper, paperboard, molded pulp, foil, wood, plastic, synthetic, or other readily destructible materials, and which are intended for one usage only, then to be discarded.

20. Vending Machine shall mean any self-service device which, upon insertion of a coin, coins or tokens, or by other similar means, dispenses unit servings of food, either in bulk or in packages without the necessity of replenishing the device between each vending operation.

21. Wholesome shall mean in sound condition, clean, free from adulteration and otherwise suitable for use as human food.

Section II. Operator's Permits--Issuance, Suspension, Revocation and Reinstatement

A. Issuance of Permit

1. It shall be unlawful for any person to engage in the operation of one or more vending machines in the municipality[27] of _____, or its police jurisdiction, who does not possess a currently valid operator's permit from the health authority. Only persons who comply with the provisions of this ordinance shall be entitled to receive such a permit.

2. Any person desiring to operate one or more vending machines in the municipality[28] of _____, or its police jurisdiction, shall make application in writing to the health authority on forms provided by the health authority. Such applicant shall provide the following information:

a. The applicant's full name, residence, and post office address, and whether such applicant is an individual, firm, or corporation. If any partnership exists, the names of the partners, together with their addresses shall be included.

b. The location of the commissary or commissaries, and of other establishments where vending machines are repaired or renovated.

c. The identity and form of the products to be dispensed through vending machines and the number of each such type vending machines in his possession.

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26. Products in hermetically sealed containers processed to prevent spoilage, and dehydrated, dry or powdered products so low in moisture content as to preclude development of micro-organisms, are excluded from the terms of this definition.
27. See footnote 1.
28. See footnote 1.

d. The signature of the applicant or applicants.

3. Upon receipt of such application, the health authority shall make an inspection of the commissary, supply storage, servicing, cleaning and sanitizing facilities, and transport facilities, and representative vending machines, and machine locations to determine compliance with the provisions of this ordinance. A numbered operator's permit shall be issued to the applicant by the health authority after compliance by the operator with the applicable provisions of this ordinance. Such permit shall not be transferable.

4. The operator's permit number, of a size and style approved by the health authority, shall be displayed and be readily visible after installation on each vending machine operated by him.

5. In order to retain an operator's permit, the operator shall:

a. Comply with the requirements of this ordinance.

b. Maintain within the jurisdiction of the health authority, a list of all vending machines operated by him within such jurisdiction and their location and of all commissaries or other establishments from which his machines are serviced. This information shall be available to the health authority upon request, and shall be kept current.

c. Notify the health authority of any change in operations involving new types of vending machines, or conversion of existing machines to dispense products other than those for which the machine was built and for which the permit was issued.

B. Suspension or Revocation of Permit

1. After an opportunity for a hearing, and following the procedures provided in section IV, an operator's permit may be suspended temporarily by the health authority upon violation by the permit holder of any of the provisions of this ordinance or may be revoked upon serious or repeated violation of such provisions, or for interference with the health authority in the performance of his duties.

2. Notwithstanding any other provisions of this ordinance, whenever the health authority finds insanitary or other conditions involving the operation of any vending machine or commissary which, in his judgment, constitutes a substantial hazard to the public health, he may without notice or hearing, issue a written order to the operator citing the existence of such condition and specifying corrective action to be taken and, if deemed necessary, requiring immediate discontinuance of operation. Such order shall be effective immediately and shall apply only to the vending machine, commissary or product involved. Any operator to whom such order is issued shall comply therewith, but upon petition to the health authority, shall be afforded a hearing as soon as possible. When necessary corrective action has been taken and upon receipt of a written request from the operator, the health authority shall make a reinspection to determine whether operations may be resumed.

3. After any hearing held under the provisions of this ordinance, the health authority shall sustain, modify, or rescind any notice or order considered in the hearing.

C. Reinstatement of Suspended Permit

Any operator whose permit has been suspended, may at any time make application for the reinstatement of the permit. Within 10 days after the receipt of a written application, accompanied by, or including, a statement signed by the operator to the effect that in his opinion the violated term or terms of this ordinance have been complied with, the health authority shall make a reinspection. If the applicant be again complying with the terms of this ordinance, the permit shall be reinstated.

Section III. Sale, Examination and Condemnation of Adulterated or Misbranded Food

A. Sale of Adulterated and Misbranded Food Prohibited

It shall be unlawful for any person within the municipality[29] of _____, or its police jurisdiction, to sell, offer, or expose for sale, through vending machines, or to have in possession with intent to sell therefrom any food which is adulterated or misbranded.

B. Examination and Condemnation of Adulterated and Misbranded Food

Samples of food may be taken and examined by the health authority as often as may be necessary to determine freedom from adulteration or misbranding. The health authority may, on written notice to the operator, impound and forbid the sale of any food which is adulterated or misbranded, or which he has probable cause to believe to be adulterated or misbranded. After the operator has been given an opportunity for a hearing, the health authority may cause to be removed or destroyed any food which is adulterated or misbranded; Provided, That in the case of misbranding which can be corrected by proper labeling, such food may be released to the operator for correct labeling under the supervision of the health authority.

Section IV. Inspection of Vending Machines and Commissaries

A. Inspection Frequency

The health authority shall inspect the servicing, maintenance and operation of vending machines dispensing potentially hazardous food and of all commissaries at least once every 6 months. Vending machines dispensing other than potentially hazardous food may be inspected by the health authority as often as deemed necessary.

B. Access for Inspections

The health authority, after proper identification shall be permitted to enter at any reasonable time, upon any private or public property within the municipality[30] of _____, or its police jurisdiction, where vending machines or commissaries are operated, or from which such machines are otherwise serviced, for the purpose of determining compliance with the provisions of this ordinance. The operator shall make provision for the health authority to have access, either in company with an employee or otherwise, to the interior of all vending machines operated by him.

C. Notification of Inspection Findings

Whenever the health authority discovers a violation of any provision of this ordinance, he shall notify the operator concerned either by the inspection report form or by other written notice. Such form or notice shall (1) describe the condition found and state which section of this ordinance is violated by such condition; (2) provide a specific and reasonable period of time for the correction of the condition; and (3) state that an opportunity for a hearing on inspection findings will be provided, if a written request for such hearing be filed with the health authority within 10 days of receipt of the notice. The health authority may also advise the operator in writing that unless the violations be corrected within the specified period of time, any permit issued under the provisions of this ordinance may be suspended or revoked, in accordance with provisions of section II, or court action may be initiated.

Section V. Sanitation Requirements for Vending Machine Operations

A. Food, Consumer Containers, Equipment Maintenance and Operations

Food intended for sale through vending machines and condiments available at vending machine locations shall be obtained from sources complying with the regulations of the municipality[31] of _____, and with other applicable State and local laws and regulations. Such food shall be wholesome, free from spoilage, and shall be processed, prepared, handled and stored in such a manner as to be protected against contamination and adulteration. All food-contact surfaces of containers and equipment shall be protected from contamination. If condiments be provided for service in conjunction with food dispensed by a vending machine, they shall be packaged in individual portions in single-service containers or shall be dispensed from approved sanitary dispensers which are washed, sanitized and filled at the commissary. Relish bowls and similar non-self-closing condiment containers shall not be used. Potentially hazardous food shall be held at safe temperatures except during necessary periods of preparation.

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29. See footnote 1.
30. See footnote 1.
31. See footnote 1.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when the following requirements are met:

1. All food offered for sale through vending machines shall be manufactured, processed, and prepared in commissaries or establishments which comply with all applicable State and local laws and regulations.[32]

2. All food offered for sale through vending machines shall be wholesome.

3. All food shall be stored or packaged in clean protective containers, and shall be handled, transported and vended in a sanitary manner. Condiments provided for service in conjunction with food dispensed by a vending machine, shall be packaged in individual portions in single-service containers or shall be dispensed from approved sanitary dispensers which are washed, sanitized and filled at the commissary. Fresh fruits which may be eaten raw without peeling may be dispensed unpackaged but must be thoroughly washed in potable water before being placed in the vending machine. Storage of cartoned, bottled, canned or packaged food by placing or submerging it in liquid is prohibited. Submerging such containers of food in ice is prohibited.

4. Potentially hazardous food offered for sale through vending machines shall be dispensed to the consumer in the individual original container or wrapper into which it was placed at the commissary or at the manufacturer's or processor's plant, or such products shall be dispensed into single-service containers from bulk containers which were filled at the commissary or at the manufacturer's or processor's plant.

5. In those vending machines which dispense potentially hazardous food from bulk, the bulk supplies of such food shall be transferred only to bulk vending machine containers and appurtenances which have been cleaned and sanitized.

6. Potentially hazardous food within the vending machine shall be maintained at a temperature of 45°F. or below, or 140°F. or above, whichever is applicable: Provided, That exceptions may be made for (a) the actual time required to load or otherwise service the machine and for a maximum recovery period of 30 minutes, following completion of loading or servicing operation; and (b) in the case of hot food vending machines, a maximum of 120 minutes to heat food through the 45°F. to 140°F. temperature zone. In hot food vending machines which are not equipped with refrigerated storage, there shall be no time delay to preclude heat from being applied to potentially hazardous food immediately after it is loaded or placed in the machine. Potentially hazardous food once heated to, or held at, a temperature of 140°F. or above, shall be maintained at such temperature until served or discarded.

Vending machines dispensing potentially hazardous food shall be provided with adequate refrigerating or heating units, or both, and thermostatic controls which insure the maintenance of applicable temperatures at all times. Such vending machines shall also have controls which prevent the machine from vending potentially hazardous food until serviced by the operator, in the event of power failure or other condition which results in noncompliance with temperature requirements in the food storage compartment.

Hot food vending machines designed to heat food through the 45° F. to 140°F. temperature range, shall also be equipped with automatic controls which render the machine incapable of vending potentially hazardous food until serviced by the operator in the event that heating through this temperature range is not accomplished in 120 minutes or less.

Potentially hazardous food which has failed to conform to the time-temperature requirements of this item shall be removed from the vending machine, and be denatured or otherwise rendered unusable for human consumption.

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32. Commissaries should comply with the applicable provisions of Public Health Service recommended 1962 "Food Service Sanitation Ordinance and Code," or substantially equivalent requirements.

Vending machines dispensing potentially hazardous food shall be provided with one or more thermometers which, to an accuracy of ± 2°F., indicates the air temperature of the warmest part of the refrigerated food storage compartment, or the coldest part of the heated food storage compartment, whichever is applicable.

7. Milk and fluid milk products offered for sale through vending machines shall be pasteurized and shall be dispensed only in individual, original containers or from bulk containers into which such product was placed at the milk plant: Provided, That such products may be reconstituted automatically within the vending machine when (a) the powder or concentrate is made from a pasteurized milk or milk product and is from an approved source: (b) the mixing chambers or bowls and any food-contact surface downstream from such mixing units are maintained at safe temperatures; and (c) the product is reconstituted for immediate dispensing in individual unit servings.

8. Milk and fluid milk products used as an ingredient in hot liquid beverages dispensed from vending machines may be transferred to a multiuse machine canister at the machine location: Provided, That (a) the location offers adequate protection against dust, insects, and other contamination; (b) the milk or fluid milk product is transferred from a dairy-filled container of not to exceed one-half gallon capacity; (c) the entire contents of such dairy-filled container are used in the transfer; (d) unused portions removed from the machine are discarded to waste; and (e) the milk or fluid milk product is poured only into an empty canister which has been effectively cleaned and sanitized at the commissary: Provided further, That milk or fluid milk products shall not be used as an ingredient under the terms of this paragraph unless the temperature of the hot beverage at the point of mixing with the milk product is 160°F. or higher.

Vending machine canisters and appurtenances used for the transfer of such milk products shall be effectively cleaned and sanitized at approved, fixed facilities at the commissary by methods approved by the health authority. After sanitization, the canister and appurtenances shall be fully wrapped in a single-service bag or cover which shall not be opened until the canister unit is installed in the refrigerated compartment of the vending machine. Canisters and appurtenances shall be so designed and constructed that the handling of contact surfaces at the machine location is unnecessary; and, such surfaces shall not be handled during canister installation, tube insertion, or product transfer.

9. All parts of any bulk milk vending machine which come into direct contact with the milk or milk product shall be effectively cleaned and sanitized at the milk plant: Provided, That single-service dispensing tubes which receive sanitizing treatment at the fabricating plant and which are individually packaged in such manner as to preclude contamination, may be exempted from this provision. The can or other bulk milk container shall be filled only at the milk plant and shall be sealed in such manner as to make it impractical to withdraw any part of its contents or to introduce any substance without breaking the seal or seals. The delivery tube and any milk-contact parts of the dispensing device shall be attached at the milk plant, and shall be protected by a moisture-proof covering, or housed in a compartment with a moisture-tight closure which shall not be removed until after the container is placed in the refrigerated compartment of the vending machine.

10. With the exception of food-contact surfaces of bulk milk vending machines for which separate provisions for cleaning and sanitizing are specified in paragraph 9 of this item, all multiuse containers or parts of vending machines which come into direct contact with potentially hazardous food shall be removed from the machine daily and shall be thoroughly cleaned and effectively sanitized[33] at the commissary or other approved facility: Provided, That the requirement for daily cleaning and sanitizing may be waived for those food-contact surfaces which are maintained at all times at a temperature of 45°F. or below, or 140°F. or above, whichever is applicable, and an approved cleaning frequency is followed. Such parts shall, after sanitizing, be protected from contamination.

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33. Recommended facilities and procedures for cleaning and sanitizing food-contact surfaces are set forth in the 1962 Food Service Sanitation Manual, P. H. S. Publication No. 934, quoted here in this Chapter.

11. All parts of vending machines which come into direct contact with other than potentially hazardous food shall be thoroughly cleaned by approved methods. The frequency of such cleaning shall be established by the health authority based upon the type of product being dispensed. A record of such cleaning operations shall be maintained by the operator in each machine or shall be made available at the time of inspection and shall be current for at least the past 30 days.

12. All single-service articles shall be purchased in sanitary cartons or packages which protect the articles from contamination, shall be stored in a clean, dry place until used, and shall be handled in a sanitary manner. Such articles shall be stored in the original carton or package in which they were placed at the point of manufacture until introduced into the magazine or dispenser of the vending machine. Single-service articles stored within the vending machine shall be protected from manual contact, dust, insects, rodents, and other contamination.

B. Machine Location

The machine location shall be such as to minimize the potential for contamination of the food, shall be well lighted, easily cleanable, and shall be kept clean. Conveniently located handwashing facilities shall be available for use by employees servicing or loading bulk food machines.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when the following requirements are met:

1. Each vending machine shall be located in a room, area, or space which can be maintained in a clean condition and which is protected from overhead leakage or condensation from water, waste or sewer piping. The immediate area in which the machine is located shall be well lighted. Each vending machine shall be so located that the space around and under the machine can be easily cleaned and maintained, and so that insect and rodent harborage is not created.

2. The floor area where vending machines are located shall be reasonably smooth, of cleanable construction, and be capable of withstanding repeated washing and scrubbing. This space and the immediate surroundings of each vending machine shall be maintained in a clean condition.

3. Adequate handwashing facilities, including hot and cold or tempered running water, soap and individual towels, shall be convenient to the machine location and shall be available for use by employees servicing or loading bulk food machines.

C. Exterior Construction and Maintenance

The exterior construction of the vending machine shall be such as to facilitate cleaning and to minimize the entrance of insects and rodents, and the exterior of the machine shall be kept clean. Service connections to machines vending potentially hazardous food or food in bulk shall be such as to protect against unintentional or accidental interruption of service to the machine.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when the following requirements are met:

1. The vending machine shall be of sturdy construction and the exterior shall be so designed, fabricated, finished, and maintained so as to facilitate its being kept clean, and to minimize the entrance of insects and rodents. The exterior of the machine shall be kept clean.

2. Door and panel access openings to the food and container storage spaces of the machine shall be tight-fitting, and if necessary, gasketed, so as to prevent the entrance of dust, moisture, insects and rodents.

3. All ventilation louvers or openings into the vending machines shall be effectively screened. Screening material for openings into food and container storage spaces of the machine shall be not less than 16 mesh to the inch or equivalent. Screening material for openings

into condenser units which are separated from food and container storage spaces shall be not less than 8 mesh to the inch or equivalent.

4. In all vending machines in which the condenser unit is an integral part of the machine, such unit when located below the food and container storage space shall be separated from such space by a dust-proof barrier, and when located above, shall be sealed from such space.

5. Unless the vending machine be sealed to the floor or counter so as to prevent seepage underneath, or can be manually moved with ease, one or more of the following provisions shall be utilized to facilitate cleaning operations: (a) The machine shall be mounted on legs 6 or more inches in height: Provided, That counter-type machines may use 4-inch legs; or (b) the machine shall be mounted on casters or rollers; or (c) the machine shall be mounted on gliders which permit it to be easily moved.

6. All service connections through an exterior wall of the machine, including water, gas, electrical, and refrigeration connections, shall be grommeted or closed to prevent the entrance of insects and rodents. All service connections to machines vending potentially hazardous food or food in bulk shall be such as to discourage their unauthorized or unintentional disconnection.

D. Interior Construction and Maintenance

All interior surfaces and component parts of the vending machine shall be so designed and constructed as to permit easy cleaning, and shall be kept clean. All food-contact surfaces of the machine shall be of smooth, nontoxic, corrosion-resistant, and relatively nonabsorbent material, and shall be capable of withstanding repeated cleaning and sanitizing by normal procedures. Such surfaces shall be protected against contamination.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when the following requirements are met:

1. The non-food-contact surfaces of the interior of vending machines shall be so designed and constructed as to permit easy cleaning, and to facilitate maintenance operations. Inaccessible surfaces or areas shall be minimized.

2. All food-contact surfaces of vending machines shall be smooth, in good repair, and free of breaks, corrosion, open seams, cracks, and chipped places. The design of such surfaces shall be such as to preclude routine contact between food and V-type threaded surfaces. All joints and welds in food-contact surfaces shall be smooth; and all internal angles and corners of such surfaces shall be rounded to facilitate cleaning.

3. All food-contact surfaces of vending machines, including containers, pipes, valves, and fittings, shall be constructed of nontoxic, corrosion-resistant, and relatively nonabsorbent materials, and shall be kept clean. In all vending machines in which carbon dioxide is used to propel water, food, or other ingredients, all food-contact surfaces in the system shall be of such material as to preclude the production of toxic substances which might result from interaction between the carbon dioxide and food-contact surfaces. All food-contact surfaces, unless designed for in-place cleaning, shall be accessible for manual cleaning and inspection: (a) without being disassembled; (b) by disassembly without the use of tools; or (c) by easy disassembly with the use of only simple tools such as a screwdriver or an open-end wrench. In machines of such design that food-contact surfaces are not readily removable, in-place cleaning of such surfaces may be permitted: Provided, That (a) they are so arranged that cleaning and sanitizing solutions can be circulated throughout the fixed system; (b) such solutions will contact all food-contact surfaces; (c) the system is self-draining or otherwise completely evacuated; and (d) the procedures utilized result in thorough cleaning of the equipment.

4. The openings into all nonpressurized containers used for the storage of vendable food, including water, shall be provided with covers which prevent contamination from reaching the interior of the containers. Such covers shall be designed to provide a flange which overlaps the opening, and shall be sloped to provide drainage from the cover wherever the collection of

condensation, moisture, or splash is possible. Concave covers or cover areas are prohibited. Any port opening through the cover shall be flanged upward at least three-sixteenths inch, and shall be provided with an overlapping cover flanged downward. Condensation, drip, or dust deflecting aprons shall be provided on all piping, thermometers, equipment, rotary shafts, and other functional parts extending into the food container, unless a water-tight joint be provided. Such aprons shall be considered as satisfactory covers for those openings which are in continuous use. Gaskets, if used, shall be of a material which is nontoxic, relatively stable, and relatively nonabsorbent, and shall have a smooth surface. All gasket retaining grooves shall be easily cleanable.

5. The delivery tube or chute and orifice of all bulk food and bulk beverage vending machines shall be protected from normal manual contact, dust, insects, rodents, and other contamination. The design shall be such as to divert condensation or other moisture from the normal filling position of the container receiving the food or beverage. The vending stage of such machines shall be provided with a tight-fitting, self-closing door or cover which is kept shut, except when food is being removed.

6. The food storage compartment within vending machines dispensing packaged liquid food shall be so constructed as to be self-draining, or shall be provided with a drain outlet which permits complete draining of the compartment. All such drains shall be easily cleanable.

7. Opening devices which come into contact with the food or the food-contact surface of the containers shall be constructed of smooth, nontoxic, corrosion-resistant, and relatively nonabsorbent materials. Unless the opening device be of a single-service type, it shall be readily removable for cleaning, and shall be kept clean. Parts of multiuse opening devices which come into contact with the food or food-contact surface of containers shall be reasonably protected from manual contact, dust, insects, rodents, and other contamination; and such parts shall be readily removable for cleaning.

E. Water Supply

Water used in vending machines shall be from an approved source, and shall be of a safe and sanitary quality. Vending machines shall be so installed and operated as to prevent the production of toxic substances in the water.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when the following requirements are met:

1. All water used in vending machines shall be of a safe and sanitary quality and from an approved source. Water used as a food ingredient shall be piped to the vending machine under pressure or brought to the vending machine in portable containers or urns which have been filled in a sanitary manner directly from an approved water supply outlet at the commissary or other approved location. Ingredient water shall not be transferred from one container to another at the machine location. Containers for the storage of ingredient water or ice, which are not a part of this closed water system, shall be designed and maintained as food-contact surfaces. Water containers or urns shall be cleaned and sanitized at the commissary or other approved facility after each use. Such portable containers shall be continuously protected against contamination from the time of sanitizing until placed in the vending machine. Protection shall be effected which will prevent unauthorized persons from tampering with or refilling the water container. All plumbing connections and fittings shall be installed in accordance with State and local plumbing regulations.

2. If used, water filters or other water conditioning devices shall be of a type which may be disassembled for periodic cleaning or replacement of the active element. Replacement elements shall be handled in a sanitary manner.

3. All vending machines which dispense carbonated beverages, and which are connected to a water supply system, shall be equipped with two (or a double) check valves; or an air gap; or a device to vent carbon dioxide to the atmosphere; or other approved device, which will provide positive protection against the entrance of carbon dioxide or carbonated water into the water supply system.

4. Where check valves are used for the protection of the water supply system, a screen of not less than 100 mesh to the inch shall be installed in the water line immediately upstream from the check valves.

5. In all vending machines which dispense carbonated beverages and which are connected to a water supply system, the ingredient water-contact surfaces from the check valves or other protective device downstream, including the device itself, shall be of such material as to preclude the production of toxic substances which might result from interaction with carbon dioxide or carbonated water.

F. Waste Disposal

All wastes shall be properly disposed of, and, pending disposition, shall be kept in suitable containers so as to prevent creating a nuisance.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when the following requirements are met:

1. All trash and other waste material shall be removed from the machine location as frequently as may be necessary to prevent nuisance and unsightliness, and shall be disposed of in an approved manner.

2. Self-closing, leak-proof, easily cleanable, plainly labeled and designated waste container or containers shall be provided in the vicinity of each machine or machines to receive used cups, cartons, wrappers, straws, closures, and other single-service items. After being emptied, each waste container shall be thoroughly cleaned. Such waste containers shall not be located within the vending machine: Provided, That an exception may be made for those machines dispensing only packaged food with crown closures; in which case, the closure receptacle may be located within the machine. Suitable racks or cases shall be provided for multiuse containers or bottles.

3. Containers shall be provided within all machines dispensing liquid food in bulk for the collection of drip, spillage, overflow, or other internal wastes. An automatic shutoff device shall be provided which will place the vending machine out of operation before such container overflows. Containers or surfaces on which such wastes may accumulate shall be readily removable for cleaning, shall be easily cleanable, and shall be corrosion-resistant. If liquic wastes from drip, spillage, or overflow, which originate within the machine be discharged into a sewerage system, the connection to the sewer shall be through an air gap.

G. Delivery of Food, Equipment, and Supplies to Machine Location

Food, food-contact surfaces of containers, equipment and supplies, shall be protected from contamination while in transit to machine location. Potentially hazardous food, while in transit and in storage on location, shall be maintained at safe temperatures.

Satisfactory Compliance. -- This item shall be deemed to have been satisfied when the following requirements are met:

1. Food, while in transit to vending machine locations, shall be protected from the elements, dirt, dust, insects, rodents, and other contamination. Similar protection shall be provided for single-service containers, and for the food-contact surfaces of equipment, containers, and devices in transit to machine locations.

2. Potentially hazardous food, prior to being loaded in the delivery vehicle, shall be maintained at a temperature of 45°F. or below, or 140°F. or above, whichever is applicable. Such food shall also comply with the applicable temperature requirements while in transit to machine locations.

3. If potentially hazardous food be stored at machine locations, the applicable safe temperature shall be maintained during storage.

H. Personnel--Cleanliness

Employees shall maintain a high degree of personal cleanliness and shall conform to

hygienic practices while engaged in handling foods, or food-contact surfaces of utensils or equipment.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when the following requirements are met:

Employees shall wash their hands immediately prior to engaging in any vending machine servicing operation which may bring them into contact with food, or with food-contact surfaces of utensils, containers, or equipment. While engaged in such servicing operations, employees shall wear clean outer garments, shall conform to hygienic practices, and shall not use tobacco in any form.

Section VI. Disease Control

No person while affected with any disease in a communicable form, or while a carrier of such disease, or while afflicted with boils, infected wounds, sores, or an acute respiratory infection, shall work in any area of a commissary or vending operation in any capacity in which there is a likelihood of such person contaminating food or food-contact surfaces with pathogenic organisms, or transmitting disease to other individuals; and no person known or suspected of being affected with any such disease or condition shall be employed in such an area or capacity. If the manager or person in charge of the establishment has reason to suspect that any employee has contracted any disease in a communicable form or has become a carrier of such disease, he shall notify the health authority immediately.

Section VII. Procedure When Infection is Suspected

When the health authority has reasonable cause to suspect the possibility of disease transmission from any employee, the health authority shall secure a morbidity history of the suspected employee or make such other investigation as may be indicated, and take appropriate action. The health authority may require any or all of the following:

1. The immediate exclusion of the employee from all commissaries and vending machine operations.

2. The immediate closure of the commissaries and operations concerned until, in the opinion of the health authority, no further danger of disease outbreak exists.

3. Restriction of the employee's services to some area of work where there would be no danger of transmitting disease.

4. Adequate medical examination of the employee and of his associates, with such laboratory examinations as may be indicated.

Section VIII. Commissaries Outside Jurisdiction of the Health Authority

Food from commissaries outside the jurisdiction of the health authority of the municipality[34] of _____ may _____ be sold within the municipality[35] of _____ if such commissaries conform to the provisions of the food-service establishment sanitation regulations of the municipality[35] of _____, or to substantially equivalent provisions. To determine the extent of compliance with such provisions, the health authority may accept reports from the responsible authorities in the jurisdictions where the commissary or commissaries are located.

Section IX. Enforcement Interpretation

This ordinance shall be enforced by the health authority in accordance with the interpretations thereof contained in The Vending of Food and Beverages--A Sanitation Ordinance and

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34. See footnote 1.
35. See footnote 1.

and Code--1965 Recommendations of the Public Health Service, three certified copies[36] of which shall be on file in the office of the clerk of the municipality[35] of _____.

Section X. Penalty

Any person who shall violate any provision of this ordinance shall upon conviction be fined not more than _____ at the discretion of the court. In addition thereto, such person may be enjoined from continuing such violation. Each and every violation of the provision of this ordinance shall constitute a separate offense.[37]

Section XI. Repeal and Date of Effect

This ordinance shall be in full force and effect 12 months after its adoption and publication as provided by law; and at that time, all ordinances and parts of ordinances in conflict with this ordinance are hereby repealed.

Section XII. Unconstitutionality Clause

Should any section, paragraph, sentence, clause, or phrase of this ordinance be declared unconstitutional or invalid for any reason, the remainder of said ordinance shall not be affected thereby.

A Guide For the Field Evaluation of Dishwashing Machines*

1. Does the dishwashing machine have affixed to it the National Sanitation Foundation Seal of Approval?
2. Are the walls and floor in the general area around the machine clean and of cleanable and impervious construction?
3. Are the fixtures adjoining the machine (clean dish and soiled dish tables, scrapping sinks, etc.) so constructed and installed that they be of cleanable construction and meet the requirements of National Sanitation Foundation Standard #2?
4. Are the dish machine, clean and soiled dish tables, and all other equipment in the dishroom so installed as to allow proper servicing of all parts of them and so all cracks and crevices which may harbor rodents and insects or accumulate dirt are eliminated?
5. Is a simple means provided for the removal of steam vapors from the dishwashing machine area?
6. Is the dishwashing machine, and the appliances in conjunction with it, installed in compliance with State and local plumbing codes?
7. Are the valves on water lines to the machine, and the appliances in conjunction with it, in good repair so as to prevent excessive leakage?
8. Does the machine appear to be in good operating and mechanical condition?
9. Are the available water heating devices adequate to meet the peak demands of 140 degrees fahrenheit and 180 degrees fahrenheit water, as determined by National Sanitation Foundation Standard #5?
10. In figuring the capacity of the waterheating devices, has adequate allowance been made for elevation above sea level?
11. If the hot water booster heater be farther than five feet from the point of use of the water at the machine, is a mechanical recirculation device provided?

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35. See footnote 1.
36. Three certified copies of this ordinance and code may be obtained for official use upon request to the Public Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C., 20201.
37. This section should be worded in accordance with community laws and the State Constitution. Where legally possible, it is suggested that a minimum fine, with an increased fine for subsequent offenses, be prescribed.

* Prepared by Committee Food Protection, Engineering and Sanitation Section, APHA 1962. See section on Dishwashing Machines in foregoing part of this Chapter.

12. Are the hot water lines insulated to prevent heat loss?

13. Does the hot water generating system itself meet the minimum requirements of National Sanitation Foundation Standard #5?

14. Is the operation of the recirculation pump of the hot water system activated in such a way as to insure operation of the pump at all times that the machine is in operation?

15. Is the machine drained and cleaned at least once each day?

16. Are the curtains and other readily removable parts removed and cleaned each day?

17. Are the scrap trays in good repair and cleaned regularly?

18. Are the overflow pipes from the various tanks clean and free of debris?

19. Is the machine free of mineral deposits and scale?

20. Where necessary, is a routine schedule followed for deliming the machine?

21. Is the receiving area adequate in size to store the maximum accumulation of soiled dishes without excessive stacking?

22. Is an adequate pre-flush unit available?

23. Are dishes being properly pre-flushed?

24. Are the dishes being washed in the proper racks?

25. Are all dishes, glasses, and silver so racked that sprays cover all portions of the pieces?

26. Is racking done according to the size and type of utensil?

27. Are adequate racks available for the peak washing periods?

28. Are the wash spray jets clean and free of deposits and debris?

29. Is an accurate indicating thermometer provided for the wash tank?

30. Is the wash water temperature maintained between 140 degrees fahrenheit and 160 degrees fahrenheit? (In the case of a single tank conveyor-type machine, is the wash water maintained at 160 degrees fahrenheit or above?)

31. Is the proper wash time being used in stationary rack machines?

32. Do the automatic timing controls comply with the applicable provisions of National Sanitation Foundation Standard #3?

33. Is detergent fed automatically or in a systematic, acceptable manner?

34. Is the detergent concentration of the wash solution between 0.2% and 0.3%?

35. If an automatic detergent dispenser be available, is it clean and functioning properly?

36. Are all rinse jets, both power and final rinse, clean and free of corrosion and deposits?

37. Are indicating thermometers provided on the machine to monitor both the recirculating rinse and the fresh water rinse in accordance with National Sanitation Foundation Standard #3?

38. Are proper rinse temperatures, as specified in National Sanitation Foundation Standard #3, being maintained?

39. Are the proper times being observed during the rinse cycles as determined by National Sanitation Foundation Standard #3?

40. Is the machine so designed or equipped to insure separation of the power and final rinse waters?

41. Is a water pressure gauge provided on the hot water supply line leading to the fresh water rinse manifold and installed as near the rinse manifold as possible?

42. Is a flow pressure of not less than 15 pounds per square inch nor more than 30 pounds per square inch being maintained on the fresh water rinse line at the machine, and a pressure of not less than 10 pounds per square inch being maintained at the rinse nozzle?

43. Is an adequate volume of fresh water rinse being delivered in accordance with the requirements of National Sanitation Foundation Standard #3?

44. If a chemical is being injected into the fresh water rinse line to facilitate free rinsing and draining of the dishes, is the rinse injector equipment in operation being maintained properly, and is it clean?

45. Does the operator of the machine make a thorough visual check of all the dishes upon taking them from the machine?

46. Are the dishes clean to the sight and touch and do they drain and dry quickly?

47. Are adequate clean dish tables available to allow complete air drying of dishes prior to stacking and storing?

48. Are clean, sanitized dishes handled in such a manner as to minimize contamination after washing?

49. Are all dish storage units clean and adequately protected to minimize the possibility of contamination in storage?

50. Are dishes stored in such a manner to minimize the possibility of contamination by handling prior to use?

Regulations and Definitions Applying to Other Aspects of Food Control.

Although a great deal of the sanitarians' activities relating to food control are centered around the preparation and distribution of food in restaurants, there are many other outlets for food to the consumer and many other places where food is produced, processed, stored, and distributed which require the sanitarian's vigilance and for which laws, ordinances, rules, and regulations exist. The U. S. Public Health Service "Ordinance and Code Regulating Eating and Drinking Establishments" which is presented above relate mainly to restaurants. Although much of the provisions of sanitation and hygiene of the latter also apply to other places where food is handled, nevertheless, for legal purposes, each type of food handling establishment must be defined, and the sanitary and hygienic aspects unique for each must be regulated. A sanitary code for food control must therefore be much more comprehensive than the above code. Such a comprehensive code was drafted by the Engineering Section Project of the American Public Health Association in developing a proposed sanitary code for Louisville and Jefferson County, Kentucky, 1948.

A food control code should give the definitions of all terms of special significance relating to regulatory activities. The definitions should include those already given for regulating eating and drinking establishments, regulating the production, transportation, processing, handling, sampling, examining, grading, labelling and sale of milk and milk products, frozen desserts, seafood, meat, poultry and eggs, and also the following definitions (quoted from the sanitary code developed by the Engineering Section Project of the American Public Health Association) not given elsewhere in this book:

Definitions

The term "food establishment" shall mean any place where food or beverage intended for human consumption is kept, stored, manufactured, prepared, dressed, slaughtered, handled, sold or offered for sale, either at wholesale or retail.

The term "wholesale food processing establishment" shall mean any food establishment or portion thereof undertaking any of the activities of such establishment for the purpose of sale or delivery to another person for the purpose of resale and shall include, among others:

a. "Warehouses" where food or beverage is stored.

b. "Food manufacturing plants" where food is prepared, cooked, canned, packed or in any way converted from the state or form in which the articles or any component parts thereof were received.

c. "Beverage manufacturing plants" where malted beverages or soft drinks are prepared and bottled.

d. "Bakeries" where bread, baked goods, pastries, etc., cooked or uncooked, are prepared.

The term "retail food processing establishment" shall mean any food establishment or portion thereof undertaking any of the activities of such establishment for sale or delivery at

retail and shall include, among others:

a. "Grocery stores" where staple articles of food commonly called groceries are handled at retail.

b. "Meat or poultry markets" where meats or poultry and eggs and their by-products are handled at retail.

c. "Fish markets" where oysters, fish or shellfish are handled at retail.

d. "Fruit or vegetable markets" where fruits or vegetables, or both, are handled at retail.

e. "Bakeries" where bread, baked goods, pastries, etc., cooked or uncooked, are handled at retail.

f. "Confectionery stores" where ice cream, carbonated beverages, candy, nuts, popcorn and like commodities are handled at retail.

g. "Restaurants" where food and drinks are handled at retail.

h. "Delicatessens" where food and/or uncooked prepared foods are sold for consumption off the premises and are not otherwise included under retail food processing establishments, fish processing plants, frozen food processing plants, and restaurants.

i. "Soft drink stands" where bottled still or carbonated beverages are sold for consumption on or off the premises when such establishments are not included in any other classification under retail food processing establishments.

The term "slaughter house" shall mean any food establishment or portion thereof in which cattle, sheep, swine, goats, or horses are slaughtered for transportation, sale, or processing as food for human consumption.

The term "poultry processing plant" shall mean any food establishment or portion thereof in which poultry are killed, dressed, processed, or stored for sale or are offered for live sale.

The term "fish processing plant" shall mean any food establishment or portion thereof in which fish or shellfish are handled, processed or packed for market or shipment as fresh fish or fresh or perishable shellfish.

The term "frozen food processing plant" shall mean any food establishment or portion thereof where food is prepared, processed, packed or stored for sale or shipment or held in storage as a frozen product and shall include among others, food quick freezing plants, food refrigeration locker plants, and frozen dessert plants.

The term "automatic food vending machine" shall mean a machine so designed and constructed that it will, on insertion of a coin in such machine, deliver food or drink to a customer in a package, in bulk or in a container. Such machines shall include, among others, those which deliver:

a. Packaged goods such as candy bars which demand consideration of quality of the product and conditions of storage in the container.

b. Bulk goods such as popcorn and peanuts which demand consideration of quality of the product, conditions of handling while filling container, and storage in the container.

c. Mixed drinks or food products combined in the serving of a drink, such as syrup bases and carbonated water, or coffee, milk, or soup, which in addition to those considerations under a. above require consideration of the handling and refrigeration of the product, the servicing of the machine, and the cleansing of the equipment.

The term "food vendor" shall mean any person who sells, offers for sale, or gives away from any wagon, truck, push cart or other vehicle or container or public market, any article of food to be used for human consumption.

The term "foodhandler" shall mean any person who in the storage, manufacture, preparation, handling, sale or serving of food, handles food in such a manner that some portion of his clothing or body might come in contact with such food or with utensils used in connection therewith.

The term "food" shall mean articles used for food or drink for man including chewing gum, liquors, and articles used as components of any article of food.

The term "flour" shall be limited to:

a. The foods defined as

1. Flour, white flour, wheat flour, plain flour.
2. Bromated flour.
3. Self-rising flour, self-rising white flour, self-rising wheat flour.
4. Phosphated flour, phosphated white flour, and phosphated wheat flour, in the definitions and standards of identity promulgated by the Federal Security Agency under date of May 26, 1941 (Volume 6, Federal Register, pages 2574-2582 inclusive), or as they may be amended but does not include special flours not used for bread, roll, bun or biscuit baking, such as specialty cake, pancake and pastry flours.

b. The term "enriched", as applied to flour, means the addition to flour of the vitamins and other nutritional ingredients necessary to make it conform to the definition and standard of identity of enriched flour, or enriched bromated, or enriched self-rising flour, as the case may be, as fixed and established by order of the Federal Security Agency on July 1, 1943 (Volume 8, Federal Register, pages 9115-9116), or as the same may be from time to time amended or modified.

c. The term "bread" includes and shall be limited to the foods commonly known and described as white bread, white rolls and white buns.

The term "food vending vehicle" shall mean any conveyance used by a food vendor offering food to be used for human consumption.

The term "food refrigeration locker plants" shall mean any establishment or portion thereof wherein compartments are rented, leased, or made available to any other person than the owner of the establishment for refrigerated storage of food.

The term "public market" shall mean the space, stall, or enclosure designated for the use of a huckster for carrying on the buying and selling of farm products.

The term "huckster" shall mean a person who offers for sale or sells on the streets, alleys, or public ways, or in a public market farm products produced by others which he has purchased directly from a grower or has received from a grower on consignment of such farm products.

The term "grower" shall mean a person who is engaged in the business of growing farm products on land cultivated by him, or his family, or his employees.

The term "condemned" shall mean that food or any food product which has been determined by inspection or analysis to be unsound, unhealthful, unwholesome, or otherwise unfit for human food.

The terms "label," "adulterated," and "misbranded" should be defined as given elsewhere in this chapter.

Regulations

Because of the special conditions existing in the sanitary and hygienic control of food such as milk and milk products, frozen desserts, meats and meat products, seafood, poultry, and eggs, special regulations have been developed for each. There are, however, certain administrative regulations which apply to food control in general, and which should be included in every type of food control code. They are as follows:

Approval of Plans Required. Any person, firm, corporation, public agency, industrial establishment or institution who desires or proposes to remodel an old building or portion thereof which is being used or is proposed to be used to conduct a food establishment, or who desires or

proposes to construct a new building which is to be used in whole or in part to conduct a food establishment, shall, prior to such remodeling or construction, submit plans therefor in triplicate to the health officer for approval.

The application shall contain complete plans of a size acceptable to the health officer, and specifications fully describing such food establishment or addition or alteration contemplated in the application and such other information as may be required hereinafter under Reports, and shall be made on forms provided for that purpose by the health officer.

The health officer shall review said plans and if they conform to the sanitation and construction requirements provided for in these rules and regulations he shall approve same and return one copy thereof with his approval written thereon. He shall retain other copies thereof for the files and records of the board of health.

If the health officer finds that said plans do not conform to said sanitation and construction requirements he shall note on all three copies of said plans the items therein which do not and the manner in which said items do not conform. And thereupon he shall hold one copy in the files and return two copies of said plans so marked to the person submitting said plans. Thereupon it shall be the duty of such person to correct and adjust such plans to conform to the sanitation and construction requirements herein set forth. When said plans have been so corrected and adjusted they shall be approved and disposed of as herein above provided.

Each food establishment shall be so located as to permit the prompt receipt and distribution of perishable foodstuffs.

a. No food establishment shall be located in the immediate vicinity of any industry or establishment or other place giving off noxious odors or which is rendered objectionable through the use or production of decomposed materials.

b. No food establishment shall be located upon a site which cannot be made sanitary nor where the refuse cannot be disposed of in a sanitary manner.

Permits Required. Every person, firm, corporation, public agency, industrial establishment or institution using, managing, or maintaining a food establishment shall hold an unrevoked permit from the board of health to do so.

The owner or the proprietor or the person responsible for the operation of a food establishment shall post and keep posted the operating permit required above in a conspicuous place in the office of wholesale food processing establishments, and in a conspicuous place visible to the public on an inside wall of a retail food establishment, restaurant, or public market, and in a place visible to the public and protected against weathering, drippage, or other drainage on food vending vehicles, or in a temporary food establishment.

The permit holder shall have the right to protest any adverse findings or orders against him provided:

1. Within the period of time set forth in a written notice, the owner or person responsible for said violation or violations shall have the right to file with the health officer a written protest against the order and finding or findings of the health officer as set forth in said notice and to request a hearing thereon before the health officer.

2. Any one who files a protest, as herein provided for, shall have the right and shall be given an opportunity to be heard, in person or by attorney, and to show that no violation or violations have been committed, or why such violation or violations should not be corrected.

a) Such hearing shall be informal and shall be held by and before the health officer or his authorized representative at such time and place and under such reasonable rules and regulations as the health officer shall designate and prescribe.

b) If after, such hearing, it shall appear that these rules and regulations have not been violated, said notice and order shall be rescinded.

c) If, after such hearing, it shall appear that these rules and regulations, or any part of them, have been or are being violated and that the owner or person notified is responsible therefor, the notice and order shall be affirmed or amended, and the affirmed or amended order, as the case may be, shall be final.

If grading of food establishments be practiced, the following food establishments shall be specifically exempted from grading but shall be required to comply with all other applicable requirements and standards of the sanitary code: Food vending vehicles, automatic vending machines, temporary food establishments, grocery stores, fruit and vegetable markets, food refrigeration locker plants, public markets, common carrier conveyances governed by Interstate Quarantine Regulation, ice plants.

Investigation of Food Establishments. The health officer shall make or cause to have made such surveys, investigations, studies and inspections of food establishments as may be necessary to determine that all food establishments are constructed, operated and maintained in compliance with applicable provisions of the sanitary code.

Free access to all food establishments shall be accorded to the health officer or his agents at all reasonable times for the purpose of inspection and examination of such places and of the food stored, manufactured, prepared, handled, sold or served therein. No person, including such person's agents and employees, shall obstruct or otherwise hinder, delay or detain the health officer or his authorized agent in making such inspections in pursuance of his duty.

The investigator shall make a written report and findings of fact of his official inspections of such food establishment, which report and findings shall be made in duplicate. One copy of the inspection report shall be posted upon the inside wall of the food establishment, and said inspection report shall not be defaced nor removed by any person except the health officer or his agent. Another copy of the inspection report shall be filed with the records of the health department.

In case the inspection report shows a violation or non-conformity with any item or items of sanitation, the health officer shall notify the person operating such establishment of such violations or non-conformities and it shall be the duty of such person to correct such violations or non-conformities within such reasonable time as may be specified in such notices. At the expiration of such period of time, the health officer shall make or cause to be made a second inspection to determine whether or not his notice has been complied with.

The health officer shall collect or cause to have collected and shall analyze or cause to have analyzed such samples of food and food products as may be necessary to determine compliance with the standards and requirements of this Code.

The health officer shall inspect or cause to be inspected each and every food establishment operating within the area of jurisdiction as many times as may be deemed necessary by the health officer.

Sale and Use of Foods. No person may sell or offer for sale, distribute, introduce or deliver for introduction to any other county of the state, or into interstate commerce; receive or permit to be received from any other county or from interstate commerce; manufacture or permit to be manufactured, use or permit to be used in food, food products, or food processing; stamp, mark, label or otherwise identify as food, pack or repack; or give away any article of food which is adulterated, misbranded, or falsely labeled, or which has been produced, prepared, manufactured, stored, packed, or distributed under unsanitary conditions or on premises which are maintained in an unsanitary condition, or which does not conform with the standards and requirements of this Code.

No meat or meat products shall be sold, kept, transported, or offered for sale in the area of jurisdiction unless such meat or meat products shall bear on such meat or meat products or the can or package containing such meat or meat products in a clear and legible manner the "inspected and passed" stamp or other recognized identification of the United States Department of Agriculture or that of the department of health, or other agency approved by the health officer except that such identification shall not be required of live poultry slaughtered, dressed or prepared locally for retail sale in accordance with the other provisions of this code.

The sale, offering for sale, or delivery of flesh of any equine animal at a store, market, or place for the retail sale of food or drink is prohibited unless the person, firm or corporation maintaining or operating such store, market or place shall have first obtained a specific permit therefor from the health officer.

When any duly authorized officer of the health department finds any article of food that is adulterated, the article shall be tagged or otherwise properly marked, giving notice that the product is suspected of being adulterated; is detrimental to public health and has been quarantined, and warning all persons not to remove it until given permission by the officer or the courts.

No person shall remove or otherwise dispose of such article in violation of this section.

Any food, drink, or any substance used in connection with the preparation of food or drink sold, offered for sale, kept or transported may be condemned, removed or destroyed by or under the direction of a duly authorized representative of the department of health, if, in the judgment of such representative, such food, drink or substance be decomposed, unwholesome, unfit for human consumption or dangerous to the public health.

Any such food, drink, or other substance may be stopped from sale or use and placed under an embargo as provided above by any such representative of the department of health for such reasonable period of time as may be required to make investigations or examinations, if such may be necessary, to determine that such food, drink or other substance is decomposed, unwholesome, unfit for human consumption or dangerous to the public health.

No such food, drink or other substance shall be used, removed, destroyed or otherwise disposed of while under such embargo except by or under the direction of such representative of the health officer or the state department of health.

(Labeling* Exemptions for Foods Repackaged in Retail Food Establishment

In 1952, the Federal Food and Drug Administration passed the following regulation concerning repackaging of foods concerning which the sanitarian must take cognizance:

A food shall be exempt from the requirement that the label bear a statement of the quantity of net contents if said food, having been received in bulk containers at a retail establishment, is accurately weighed, measured or counted either within the view of the purchaser or in compliance with the purchaser's order.

A food shall be exempt from the requirement that the label bear a declaration of the common or usual name of each ingredient when the food is fabricated from two or more ingredients, if said food, having been received in bulk containers at a retail establishment, is displayed to the purchaser with either (1) the labeling of the bulk container plainly in view or (2) a counter card, sign or other appropriate device bearing prominently and conspicuously the list of ingredients in the food.

A food shall be exempt from the requirement that the label bear a statement of any artificial flavoring, artificial coloring, or chemical preservatives if said food, having been received in bulk containers at a retail establishment, is displayed to the purchaser with either (1) the labeling of the bulk container plainly in view or (2) a counter card, sign, or other appropriate device bearing prominently and conspicuously a declaration of any artificial flavoring, artificial coloring, or chemical preservatives in the food.) (end of insert).

Reports. It shall be the duty of every person, firm, corporation, public agency, municipality, school, church, hospital, industrial establishment, or institution holding a permit to operate and maintain a food establishment and of every employee of such permit holder to furnish such records and information as the health officer may deem necessary to ascertain that all applicable provisions of the sanitary code are being complied with.

Standards for Food Establishments

(Standards for "Food Establishments" in general are practically the same as for "Restaurants" in particular, therefore refer to the requirements relating to floors, walls and ceilings, doors and windows, lighting, ventilation, lavatory facilities, water supply, utensils and equipment, cleaning and bactericidal treatment, storage and handling of utensils and equipment, disposal of wastes, refrigeration, cleanliness of employees and premises and disease control in the U. S. Public Health Service Code Regulating Eating and Drinking Establishment quoted hereinbefore.)

*Insert

Custard Filled Pastry Standards and Requirements. The term "custard mix" and "custard filler" as used herein shall refer to any product, consisting principally of flour, sugar, eggs and milk, with or without cornstarch, heated, cooled, and applied to pastry without subsequent heating. The provisions of this section shall also apply to custard-filled pastry commonly designated as cream puffs and eclairs which may be heated subsequent to filling.

The sale, offering for sale, or delivery of any pastry containing a custard filler is prohibited unless the person, firm, or corporation manufacturing such custard-filled pastry shall have first obtained a specific permit therefor from the health officer.

The entire custard mix to be used in the manufacture of custard-filled pastry under such permit shall be brought to a temperature of not less than 200 degrees F., maintained at not less than that temperature for a period of not less than ten minutes, and within one hour thereafter placed in a refrigerating temperature of not over 50 degrees F. and kept at or below such temperature until applied to the pastry. A proper record of the manufacture of each and every lot of custard filler and the time of the filling operation shall be maintained on a form furnished by the department of health and all such data shall be entered on such record form at the time each operation is performed.

No custard-filled pastry shall be sold either wholesale or retail or transported for retail delivery unless it shall be wrapped or packaged so as to protect the contents from contamination and such wrapper or package shall bear prominently displayed on the outside thereof in legible letters the name of the manufacturing baker, and day of manufacture, and the following statement: "REFRIGERATE AND CONSUME TODAY". No custard-filled pastry shall be displayed, offered for sale, or sold except on the day of manufacture thereof. The day of manufacture shall be the day on which the custard mix is heated and the manufacture of the custard-filled pastry completed but may include not more than the two hours preceding midnight of the previous day.

No custard-filled pastry shall be kept, displayed, or offered for sale in or from any bakery, store, place or vehicle unless it shall have been refrigerated at a temperature not over 50° F. from the time of manufacture until the time of delivery to the consumer. Between the first day of May and the first day of October of each year no such pastry shall be transported in any vehicle unless it be kept at or below 50 degrees F.

Custard-filled pastry manufactured, kept, or offered for sale in violation of the provisions of this section is hereby declared to be dangerous to the public health and as such subject to condemnation by any authorized representative of the department of health.

Coin Operated Food or Beverage Dispensing Machine. The following standards shall be used for coin operated cut type vending machines dispensing hot and cold, still or carbonated drinks not classified under Milk and Milk Products of the sanitary code.

Design and Construction shall meet these requirements:
The machine shall be so designed and finished that it can easily be maintained in a clean and sanitary condition.

Adequate means should be provided for inspecting and cleaning the floor under the machine. This shall be accomplished by elevating the machine to a sufficient height for proper cleaning (not less than four inches), by making the machine easily movable, or by other methods approved by the health officer having jurisdiction. This height requirement is not applicable to machines permanently fastened to the floor in such a manner as to prevent unsanitary conditions. It is recognized that there may be in existence or developed later, other suitable means of accomplishing the desired results and any such means consistent with the requirements of the health officer shall be permitted.

The cup and drink dispensing opening shall be protected from dust, dirt and insect contamination by suitable self-closing devices.

All containers, pipes, conduits and valves shall be readily cleanable and shall be of smooth, non-corrosive, non-toxic material and construction. Machines shall be designed to permit circulation throughout of accepted cleaning and sanitizing solutions. Containers, pipes, conduits, and

valves, where possible, shall be so designed as to be readily removable and readily dismantled for inspection, cleaning and sanitizing. In coffee vending machines all containers, pipes, conduits and valves with which coffee, cream or milk comes in contact shall be readily removed and disassembled.

Water filters or other water conditioning devices, if any, shall be of such type as to permit periodic internal cleaning and/or replacement of the active element.

All machines shall be designed so that the water and ingredients can be readily added in a sanitary manner and without introducing contamination. Openings in tanks and containers shall be so designed as to prevent moisture or leakage on the surface or top from entering the tank or contaminating any part coming in contact with the ingredients.

All machines shall be so designed that cups and utensils can be added directly from the original wrapping or container without handling the surface of the cup or utensil. Protection shall be provided for the cups or utensils against dust, leakage and other contamination.

No container for waste cups and utensils shall be installed or used in a machine. Suitable facilities for disposing of such waste material shall be provided convenient to the machine.

Drip containers, if any, shall be readily removable for cleaning. Machines shall be equipped with adequate safety features to prevent overflow.

Water supply inlets shall comply with the applicable provisions of this Code.

Machines shall comply with the provisions for utensils and equipment, cleaning and bactericidal treatment, storage and display of food and drink as required for food establishments.

Operation of such machines shall meet these requirements:
Each person, firm, corporation or partnership that is actually responsible for the maintenance or servicing of such a machine or machines shall provide adequate means for the proper storing, transportation, and handling of supplies and for servicing and sanitizing machines and equipment. Such supplies shall be produced, mixed, packed, and/or maintained in a sanitary condition and ingredients shall comply with all applicable pure food requirements of the sanitary code.

Each machine shall be located in a space where it is protected from filth, overhead leakage and other sources of contamination.

Each machine shall be so located that the space around it can be readily cleaned and so that no insect or vermin harborage is created.

On each premises suitable, adequate sanitary plumbing facilities should be available for emptying waste containers, and cleaning drip pans or other similar parts of the machine. Adequate facilities with hot and cold running water shall be available for the service man to wash his hands properly before handling surfaces, parts or containers that may come in contact with the ingredients or drink containers. Any part of the machine that comes into contact with any component of the food or beverage shall be washed and sanitized at a place adequately equipped with hot and cold running water. Slop sinks and lavatories are not considered proper places for cleaning and sanitizing such equipment.

The operator shall assist the health officer in making inspections of the interior of the machines at all reasonable hours, even on short notice, by providing a representative of the operator to accompany the health officer or his agent on request.

Each machine shall be serviced as frequently as is necessary to maintain it in proper sanitary condition.

Each machine shall be filled only with ingredients, including water, which have been packaged under sanitary conditions in a room separate from other operations, and properly stored in a sanitary storage room and shall be transported to the machine in closed sanitary containers, except that potable water may be added through an approved water connection to the machine or be carried from an approved tap near the machine in a sanitary container.

Contents of partially empty ingredient containers shall be adequately protected from dust, dirt and other contamination while being transported from one location to another or while in storage.

Ingredients and cups shall be delivered to and put into the machine in such a manner as to avoid possibility of contamination.

Each machine and location shall be maintained in a manner so as to prevent any nuisance or unsanitary condition.

Such machines shall conform with all requirements for food establishments not in direct conflict with the special requirements permitted for coin operated food and beverage dispensing machines.

Each such machine shall be considered as one operating unit of a food establishment comprising a group of machines and the food preparation, transportation and servicing equipment under one management.

Food Quality, Adulteration, Misbranding. No person shall manufacture, produce, expose, offer or possess for sale or sell any article of food in the area of jurisdiction that is adulterated or misbranded.

Any article intended only for shipment to another county in the state shall be subject to all of the applicable terms and provisions of the State laws.

Any article intended only for shipment to another state shall be subject to all applicable portions of the Federal Food, Drug and Cosmetic Act.

Any article likely to be sold in the county and another state; in the county and another county; or in the county, another county, and another state shall be subject to all of the provisions above which govern.

Any article of food that is adulterated but not misbranded, and does not contain any added poisonous or deleterious ingredient, and that is not otherwise adulterated within the meaning of the State law, and that does not contain any filler or ingredient that debases without adding food value, may be manufactured or sold if it be labeled, branded or tagged so as to show its exact character.

Articles of liquor that do not contain any added poisonous or deleterious ingredients shall not be deemed adulterated or misbranded if they be labeled, branded or tagged so as to plainly indicate that they are compounds, imitations or blends, and the word "compound," "imitation" or "blend" as used in this sub-section means a mixture of like substances, not excluding harmless coloring and flavoring ingredients used for the purpose of coloring and flavoring only.

Methods for analysis of samples and the standards for determining adulteration or misbranding shall be those fixed under the provisions of the State law, but if it be found that such methods or standards are not applicable to a particular food then the health officer shall determine a method and a standard which shall be used until an applicable method or standard has been adopted by the state board of health.

Labeling of food shall conform to requirements of the State law, or applicable portions of the Federal Food, Drug and Cosmetic Act, whichever is applicable.

Provisions for guaranty by the manufacturer or wholesaler shall be those established in the State law or the Federal Food, Drug and Cosmetic Act, whichever is applicable.

See chapter on Poultry and Eggs for regulations pertaining to the quality of eggs.

Transportation of Food. The Department of Health, Education and Welfare, Public Health Service Interstate Quarantine Regulations, published in Federal Register, May 16, 1947, shall be applied and enforced when requested, when food used or intended to be used for human consumption is supplied by carriers subject to Federal Quarantine Regulations.

Any person, firm, corporation, municipality, public agency, school, church, or institution who transports, distributes, or operates equipment intended to transport or distribute food for human consumption in the area of jurisdiction shall hold an unrevoked food vending vehicle permit issued by the board of health unless specifically exempted.

Such persons holding a permit for the operation of a food establishment shall have incorporated in that permit the terms and conditions applicable under Transportation of Food.

Such persons who do not operate food establishments, but transport or deliver food as a separate business not under the supervision of a food establishment under permit, shall obtain a permit in accordance with this Section.

Growers transporting unprocessed farm products to be sold only to or in a food establishment shall not require a permit, but shall hold an unrevoked permit if any portion of the produce be offered for sale or exchange or otherwise distributed within the meaning of the term food vendor.

Permits shall be applied for in the manner prescribed for food establishment operating permits.

Food, food products, or drink distributed in a food vending vehicle shall conform to the standards and requirements of Sections "Sale and Use of Food" and "Food Quality, Adulteration, Misbranding."

Every vehicle, conveyance, push cart, trailer or food vending vehicle of any kind shall meet the following requirements:

Floors, shelving, container holders, side walls, roofs and all similar objects on which food or food containers may be carried or come in contact shall meet applicable construction standards provided under "Standards for Food Establishments."

Food vending vehicles shall have lighting equipment appropriate to the need available for lighting during times of placement or removal of food from such vehicle. When food is sold from such vehicles during the hours of darkness, the lighting equipment shall provide not less than five foot candles at the face of any shelf, or storage, or display space during the sales period.

Any water used on or in any article of food on a food vending vehicle and water carrying equipment used for carrying such water on such vehicles shall meet the requirements of the Code on Water Supplies.

Food utensils and equipment on food vending vehicles shall conform to the requirements under "Standards of Food Establishments."

Food utensils and equipment shall be cleaned in accordance with the provisions under "Standards of Food Establishments."

Food utensils and equipment shall be stored and handled in conformance with "Standards for Food Establishments".

Waste, garbage, trash, and rubbish, and any plumbing associated with the conveyance, or distribution or dispensing of food from a food vending vehicle shall be treated in conformance with provisions under Standards for Food Establishment.

Refrigerating equipment and facilities shall be provided for the preservation of perishable foods in conformance with "Standards for Food Establishments".

No catering services shall be permitted to transport cooked foods or prepared foods ready for service in other than properly designed and constructed thermally controlled boxes or containers. Foods required to be refrigerated or served hot must maintain temperatures of 40 degrees F. or less for cold, and 150 degrees F. or more for hot, at all times during handling and transport and shall be condemned as unfit for human food if not so held. Foods which may be transported at or near room temperature without danger shall be adequately protected at all times and shall conform with the requirements of "Standards of Food Establishments".

No person affected with a communicable disease or is a carrier of same shall be employed or shall perform the work of a food vendor.

The holder of a permit under which a food vending vehicle is operated shall be the person responsible for all conditions pertaining thereto found to be in non-compliance with this section.

Failure to maintain the standards and requirements for transportation of food will constitute cause for revocation of the permit under which such vehicles are operated.

Permits shall be revoked in the manner provided under section "Permits Required."

Every food vendor and the operator of every food vending vehicle shall furnish from time to time upon demand, such information as the health officer may require to determine that the requirements and standards for food vending vehicles have been and are being and can be complied with.

Meats, Fish and Poultry. The basic regulations for meat, fish and poultry are the same as for food in general in regards to permits, transportation, and administrative procedure. Federal regulations for meat, fish and poultry are given in the Chapters on these subjects. Most of these regulations could be adapted for State and local usage. State and local sanitary requirements for food establishments selling or preparing for sale of meat, fish, shellfish, poultry, game, or fowl of any kind intended for human consumption, are practically the same as the provisions of the U. S. Department of Agriculture for meat inspection, quoted under Meat Control, for such items as lighting, ventilation, racks, and receptacles, tables and benches and the like, trucks or receptacles for holding diseased carcasses, disinfecting procedure and techniques, final inspection places, places where condemned articles are held, places where articles are held for further inspection, denaturing facilities, lockers for brands, facilities for inedible products, cold storage compartments, skewers, knives, whetstones, knife scabbards, offal disposal, permits, antemortem inspection procedures, post-mortem inspection procedures, marking, stamping, labeling, and communicable disease control among food handlers.

On the State and local level, special permits may be required where pork is treated or stored for the purpose of killing trichinae, and railroad companies and other carriers may be required to notify the health department upon bringing into the area of its jurisdiction for delivery any fresh or cold storage meats or fish intended for human consumption.

Frozen Food Lockers. Requirements for food establishments processing or storing frozen foods in a frozen food locker plant:

No article of food shall be stored in any frozen food locker plant unless it be in a proper condition for storage and meets all the requirements and such rules as may be established by the said board of health for the sanitary preparation of food products which are to be stored.

Goods not intended for human consumption shall not be stored in a frozen food locker plant except such items of animal or vegetable matter which may have been approved by the health officer.

Any plant using a toxic gas refrigerant shall have at least one gas mask of a type approved by the U. S. Bureau of Mines for the particular exposure involved and shall keep the same where it will be readily accessible.

The refrigeration system for a locker plant shall be equipped with accurate and reliable controls for the automatic maintenance of uniform temperatures as required in the various refrigerated rooms and shall be of adequate capacity to provide under extreme conditions of outside temperatures and under peak load conditions in the normal operations of the plant, the following temperatures in the several rooms respectively:

Aging Room. Temperature of 34 degrees above zero F. plus or minus two degrees with a tolerance of five degrees F. for a reasonable time after fresh food is put in for aging.

Sharp Freeze Room. Sharp Freezing Compartments. Temperatures of ten degrees below zero F. or lower, or temperature of zero degrees F. or lower, when forced air circulation is

employed with a tolerance of five degrees F. for either type of installation for a reasonable time after fresh food is put in for freezing.

Locker Room. Temperature of not to exceed zero degrees F. with a tolerance of three degrees F. higher.

The foregoing temperatures shall not be construed as prohibiting such variations as may occur during short periods of time incidental to defrosting. For experimental purposes, the health officer, upon application in writing, may authorize for a limited and prescribed period the installation and use of refrigeration systems or methods which, in the opinion of the health officer will result in improvement over present methods.

No food shall be placed in a locker unless such foods have been inspected by the operator. No unwrapped meat or unwrapped or unpacked fruits or vegetables shall be placed in any locker. Only paper suitable for the wrapping of meats that are to be frozen and stored, shall be used. Each wrapped portion shall be marked or stamped with the correct locker number and the date of wrapping.

An accurate direct reading thermometer and an approved recording thermometer shall be installed in each locker room. The discs and direct reading temperature records shall be kept at the plant and shall be preserved for at least one year from the date of recording. The thermometers shall be placed in a position where they are readily observable by patrons.

All self-recording thermometers shall be of a type approved by the health officer and shall meet the following specifications:

a. Moisture-proof, enamelled metal case with lock.

b. Scale range at least minus 30 degrees F. to plus 70 degrees F. of the reverse type, i.e., low temperatures on outside of chart, and accurate within one degree F. plus or minus between minus five degrees F. and plus five degrees F.

c. Scale divisions one degree each between minus five degrees F. and plus five degrees F., the space between the lines not less than 1/27 inch and ink line not to exceed 1/40 inch in width.

d. The time represented by one scale division shall not exceed one hour, the chart to make one revolution in seven days and to be so graduated. The clock mechanism shall be spring-actuated either electric or hand-wind. If electric wind be used, the spring shall be capable of maintaining accurate time for thirty hours. Hand-wind recording thermometers shall be capable of operating for seven days without rewinding.

e. The rotating mechanism shall be provided with a pin to puncture the charts in a manner to prevent fraudulent rotation of charts.

f. Provided that recording thermometers not in compliance with the above specifications but for which a bona fide order was placed with the manufacturer or manufacturer's agent prior to date of adoption of these regulations such thermometers shall be considered as being in compliance until such time as major recording thermometer shall be rebuilt, or a new recording thermometer shall be purchased to comply with specifications.

g. The direct-reading thermometer in the locker room, and the bulb of the recording thermometer, shall be installed so as to indicate the temperature of the warmer levels of the locker room and in general shall be located in the upper third of the distance from floor to ceiling, and they shall not be placed in a direct blast of air from a cooling unit nor near a cooling coil or other heat-exchange device, nor near the entrance door. The direct-reading thermometer in the locker room shall be installed near the bulb of the recording thermometer.

Drugs, Cosmetics, Drug Stores. Drug and cosmetic laws are usually included together with food laws because the basic control factors, namely, permits and prevention of adulteration and misbranding are the same. Although the basic regulatory laws are the same for both categories, food is by nature different from drugs and cosmetics, and therefore the rules and regulations made to administrate these laws are different for each. The following drug and cosmetic regula-

tions were developed by the Engineering Section Project of the American Public Health Association to apply to the retail handling of drugs and cosmetics which, of course, generally takes place in drug stores.

Whenever any establishment commonly called a drug store shall operate on any portion of the premises a business consisting of a food establishment, an industrial establishment, or any other establishment requiring a permit therefor, then the owner or manager or operator of such drug store shall hold each or the several operating permits required for the particular use.

Applications, permits, investigations, samples and all other requirements of the sanitary code applicable to any specific premises use shall be applicable to that portion so used, but may, if the health officer so directs, be combined into one comprehensive operating permit setting forth therein all of the uses permitted and any or all specific terms and conditions required for each of the several permits, had such permits been issued separately.

Any drug store or establishment of the character of a drug store shall conform to all applicable requirements of the sanitary code, whether or not operating under any form of permit.

The health officer shall make or cause to have made such surveys, investigations and studies of housing, occupancy and use of premises as may be necessary to determine that the provisions of this chapter and of the sanitary code are being complied with.

The health officer shall make or cause to have made any tests, any chemical or bacteriological analyses of samples or any measurements, which may be required for the purpose of determining compliance with the requirements and standards of this chapter or any other applicable provision of the sanitary code.

It shall be unlawful for any person, co-partnership, corporation, enterprise or association except such persons operating in such manner as is specified below, to sell, give away, or otherwise distribute to the public in stores, on the streets, by vending machines, by peddling from house to house, or in any public place or office building, or in any manner whatsoever, within the area of jurisdiction, any appliance, drug, or medicinal preparation intended or having special utility for the prevention of conception and/or venereal disease, or any other treatment, substance, drug, chemical, which may be harmful, toxic or dangerous to health in limits above those prescribed by the health officer.

It shall be unlawful for any person, co-partnership, corporation, or association to display or expose for sale, any appliance, drug, or medicinal preparation intended or having special utility for the prevention of conception and/or venereal disease, or to display or expose any containers or packages therefor, descriptive or suggestive of the contents or to advertise the sale of the same on placards, billboards, handbills, newspapers, periodicals, signs, or by any means of publication either visual or auditory, either individually or by broadcast, within the area of jurisdiction, but the prohibition of this section shall not extend to medical and drug publications, the circulation of which are confined substantially to physicians and the drug trade.

The prohibition specified herein shall not apply to wholesale dealers to the extent that such wholesale dealers are permitted to sell or distribute appliances, drugs and medicinal preparations specified above (but only such as conspicuously bear the identification of the manufacturer thereon, or the retail container thereof) only to regularly licensed druggists; nor shall the prohibition specified above apply to the sale or distribution of such appliances, drugs or medicinal preparations by regularly licensed practitioners of medicine in the normal course of their professional activities; nor shall the prohibition specified above apply to the sale of such appliances, drugs or medicinal preparations by licensed druggists, provided such sales are made only from the prescription counters of such drug stores by registered pharmacists there employed and only to persons more than 18 years of age, and only after proper registry and/or on authorized prescription when required by law.

The following specific requirements shall apply to the sale of drugs, narcotics, cosmetics, dangerous poison, chemicals or other such substances offered for sale, trade or gift and shall be in addition to any other requirements of the sanitary code.

The following apply to the control of narcotics:

A narcotic license or certificate of approval shall be prominently displayed in the place to which it applies.

No narcotic license or certificate of approval shall be considered valid and in good standing unless the indicated activity be conducted at the address stated thereon.

A narcotic license or certificate of approval shall be promptly returned to the department having jurisdiction upon revocation or suspension or when the activity for which the applicant is licensed or approved has been discontinued.

No physician, dentist or veterinarian shall obtain narcotic drugs for his professional use except by means of his official written order form.

A person authorized by law to obtain narcotic drugs on official written order forms shall not use such drugs for the treatment of his own addiction.

The body of a narcotic prescription shall be filled in with ink, indelible pencil or typewriter. The signature of the physician must be in ink or indelible pencil.

No prescription calling for a mixture containing narcotics and other ingredients shall be filled by supplying only the narcotic drug.

All records shall be readily available and promptly produced upon request for inspection by a narcotic investigator.

The health officer shall carry out upon request any investigation, study, inspection or survey of drugs, drug stores, pharmacies or any such establishment or product requested by the state department of health, or the Food and Drug Administration of the Department of Health, Education and Welfare.

The state laws or the provisions of the Federal Food, Drug and Cosmetic Act, whichever is applicable, shall be applied in the above investigation.

Every drug store, pharmacy, or similar establishment shall be maintained in a clean, sanitary condition at all times in conformance with all applicable provisions of the sanitary code, whenever and under whatever conditions applicable.

A drug store shall have the latest edition of the United States Pharmacopeia and the National Formulary. (A copy of "Materia Medica, National Dispensatory or Remington's Treatise on Pharmacy" is recommended in addition).

The prescription laboratory shall be completely and entirely separated from the sales department. The prescription department shall be orderly and clean. The walls and ceiling of the prescription department shall be finished with some light colored finish or paint. It shall be provided with adequate light, either natural or artificial. It shall be provided with light finished storage space in shelves or cabinet compartments for all equipment. It shall have suitable sinks and washing facilities for complete equipment, and handwashing facilities for employees. A prescription counter of suitable impervious material must be provided.

Minimum equipment for prescription laboratory shall consist of the following apparatus and glassware: three metal and one rubber spatula; two 4-oz., one 8-oz., one-16-oz., or equivalent mortars; graduates minim, 1-oz., 4-oz., 8-oz., one or more pill tiles, graduated glass or porcelain; one suppository mould or machine; stirring rods, glass or rubber; and small funnel, rack and filler paper for eye prescriptions, and suitable dropper bottles.

Every drug store compounding or filling prescriptions shall have a Torsion or Troemner type box or beam scale accurate to grains below 5; grain weights in duplicate, 1 to 5; scruple weight in duplicate, 1/2 to 2; drachm weights in duplicate, 1/2 to 2; one complete set of metric weights.

Biologicals shall be stored in accordance with the following:

All pharmaceuticals sensitive to light, air, heat or change of temperature shall be stored in accordance with specifications set forth in the latest edition of the United States Pharmacopoeia or National Formulary.

All vaccines, virus and serums recognized as official by the current edition of the United States Pharmacopeia shall be kept until used at a temperature between 4.5 degrees C., and 20 degrees C., approximately 40 degrees F. to 68 degrees F., preferably at the lower limit as indicated in the United States Pharmacopoeia. All vaccines, virus and serums official in the United States Pharmacopoeia, current edition, found on inspection to be kept at a higher temperature than that required in the Pharmacopoeia, shall be deemed adulterated and unfit for usage and shall be stamped or marked plainly on the label by an authorized drug inspector with the words: "not stored at required temperature", together with the date of inspection and the initials of the inspector.

Administration of Regulatory Aspects of Food and Drug Control.

In a complex world, the administration of health programs becomes a complex problem. In fact, it becomes so complex that administrative agencies must be vested with administrative rule-making by their legislative bodies in order to carry out the broad principles of law enacted by the legislatures, lest the execution of the laws become bogged down in legalistic minutiae. This is indeed true for any health agency, national, state, or local, attempting to safe-guard the food, drug, and cosmetic supply to any large public in a fast moving scientific and social world. In order to carry out a food and drug control program the administrative agency in order to be efficient and effective, should be vested with the following administrative authority:

1. Rule-Making

It should be able to make rules and regulations:

a) Defining techniques, sanitary requirements, standards of equipment and materials, and methods of identifying the food or drug article.

b) For emergency situations.

c) For the use of discretion in exceptional cases.

2. Licensing and Certification

It should be able to employ a system of:

a) Granting, revoking, suspending and refusing licenses or permits to engage in a particular activity relating to the production, storage, and distribution of food and drugs.

b) Emergency permit control.

c) Registration of foods or drugs.

d) Certification of coal-tar colors.

3. Examination and Investigation

It should be able to:

a) Enter an establishment to perform an inspection of the physical premises to detect a violation, to aid in the compliance with the law, or to determine the granting or revocation of a license.

b) Collect samples of foods and drugs for analysis.

c) Inspect records related to production and shipment of foods and drugs.

4. Enforcement.

It should be able to:

a) Condemn and seize unsafe or misrepresented articles.

b) Destroy or cause to be destroyed unsafe articles.

c) Demand injunction proceedings where health hazards or frauds exist.

d) Muster to its support quick and effective criminal prosecution.

5. Hearings.

It should be able to hold hearings in relation to:

a) Inspections giving owner or consignee the right to introduce testimony before the administrator.

b) Prosecution violations - before reporting case to attorney.

c) Licensing - prior to restoring a license or permit summarily suspended; on application or registration of a new food or drug; prior to suspension of an already granted application of a food or drug.

d) Issuance of rules and regulations - prior to the issuance.

The Federal Food, Drug, and Cosmetic Act.

Rule-Making

This act lays down the general provisions for the administration of control of foods, drugs, and cosmetics by the Administrator of the Department of Health, Education and Welfare and places authority in the latter to promulgate regulations for the purpose of carrying out the details arising from the intent of the Act.

"The authority to promulgate regulations for the efficient enforcement of this Act, except as otherwise provided . . . . is hereby vested in the Administrator"* (Sec. 701, a).

Licensing and Certification.

This Act provides for the granting, revoking, suspending and refusing of permits for manufacturing, processing or packing of food during an emergency situation only. State and local laws or regulations usually make provisions for such regulatory procedure as a routine rather than emergency course of procedure.

"Whenever the Administrator finds after investigation that the distribution in interstate commerce of any class of food may, by reason of contamination with microorganisms during the manufacture, processing, or packing thereof in any locality, be injurious to health, and that such articles have entered interstate commerce, he then, and in such case only, shall promulgate regulations providing for issuance, to manufacturers, processors, or packers of such class of food in such locality, of permits to which shall be attached such conditions governing the manufacture, processing, or packing of such class of food, for such temporary period of time, as may be necessary to protect the public health; and after effective date of such regulation, and during such temporary period, no person shall introduce or deliver for introduction into interstate commerce any such food manufactured, processed, or packed by any such manufacturer, processor, or packer unless such manufacturer, processor, or packer, holds a permit issued by the Administrator as provided by such regulations.

"The Administrator is authorized to suspend immediately upon notice any permit issued under authority of this section if it is found that any of the conditions of the permit have been violated. The holder of a permit so suspended shall be privileged at any time to apply for reinstatement of such permit and the Administrator shall immediately after prompt hearing and an inspection of the establishment, reinstate such permit if it is found that adequate measures have been taken to comply with and maintain the conditions of the permit, as originally issued or as amended." (Sec. 404, a. b.)

This Act also provides that new drugs must be registered but makes no such provision for new cosmetics.

"No person shall introduce or deliver for introduction into interstate commerce any new drug, unless an application filed pursuant to subsection (b) is effective with respect to such drug." Subsection (b) states: "Any person may file with the administrator an application with respect to any drug . . . . Such person shall submit to the Administrator as a part of the application (1) full reports of investigations which have been made to show whether or not such drug is safe for use; (2) a full list of the articles used as components of such drug; (3) a full statement of the composition of such drug; (4) a full description of the methods used in, and the facilities and controls used for, the manufacture, processing, and packing of such drug; (5) such samples of such drug and the articles used as components thereof as the Administrator may require; and (6) specimens of the labelling proposed to be used for such drug." (Section 505, a., b.)

The Act provides for the certification of coal-tar colors for foods, drugs, and cosmetics.

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*Refers to the Administrator of the Department of Health, Education and Welfare.

"The Administrator shall promulgate regulations providing for the listing of coal-tar colors which are harmless and suitable for use in food and for the certification of batches of such colors, with or without harmless diluents." (Section 406, b) The same wording is used for drugs and cosmetics.

Examination and Investigation.

"The Administrator is authorized to conduct examinations and investigations for the purpose of this Act through officers and employees of the Agency* or through any health, food, or drug officer or employee of any State, Territory, or political subdivision thereof, duly commissioned by the Administrator as an officer of the Agency. . ." (Section 702 (a)).

"For the purpose of enforcement of this Act, officers or employees duly designated by the Administrator, after first making request and obtaining permission of the owner, operator, or custodian thereof, are authorized (1) to enter at reasonable times, any factory, warehouse, or establishment in which food, drugs, devices, or cosmetics are manufactured, processed, packed or held, for introduction into interstate commerce or are held after such introduction, or to enter any vehicle being used to transport or hold such food, drug, devices, or cosmetics in interstate commerce; and (2) to inspect at reasonable times, such factory, warehouse, establishment or vehicle and all pertinent equipment, finished and unfinished materials, containers, and labelling therein." (Section 704)

"Where a sample of a food, drug, or cosmetic is collected for analysis under this Act the Administrator shall, upon request, provide a part of such official sample for examination or analysis by any person named on the label of the article or the owner thereof, or his attorney or agent; except that the Administrator is authorized, by regulations, to make such reasonable exceptions from, and impose such reasonable terms and conditions relating to, the operation of this sub-section as he finds necessary for the proper administration of the provisions of this Act.

The evidence which a sample provides covers several points which the Government must prove in order to establish its case. Collection of a sample will accomplish these things:

1. Provides portions of, or exhibits of a lot of foods, so that the laboratory can make examination to determine if the foods be in violation of the law.

2. Provides a report of the inspector's observations of the lot.

3. Provides copies of labels and labeling which accompany the product.

4. Provides documentary evidence of government jurisdiction over the lot, and yields information about names of persons responsible for the violation, when the violation was committed, and similar facts.

5. Provides signed statements of persons who can be called as witnesses, if there be a court action.

Types of Samples

Samples are classified by the Federal Government as to the manner in which they are used in the enforcement of the Federal Food, Drug, and Cosmetic Act. This classification is reasonably well recognized by the States. Each of these types has a separate function.

Official Samples. This is the most important type (1) because official samples are the bases for specific legal actions, (2) because collection of them is more complex, (3) and because more of this type are taken than others. To be significant, an official sample must be:

1. Accompanied by records showing evidence that it comes under government jurisdiction.

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*Refers to Department of Health, Education and Welfare.

2. Representative enough to demonstrate the violation suspected.

3. Large enough to permit proper laboratory examination.

4. Handled and identified so as to maintain its integrity as court evidence.

Investigational Samples. This type of sample is not used as a basis for a specific legal action, but it serves to provide information which can be applied in many different ways. Investigational samples are commonly spoken of in abbreviated form as "INV's". Compared to the rules and requirements for collection of official samples, the procedures for investigational samples are not rigid. This does not mean that INV samples are unimportant or that the collection of them can be done in a haphazard manner. Some INV samples are introduced as evidence in court, and their integrity must be well established.

1. Factory samples consisting of photographs, exhibits of filth, samples of raw materials or finished products, or any other material taken during establishment inspections. These samples demonstrate manufacturing conditions, and may be used as evidence in court. They are sealed and handled so as to protect their integrity.

2. Samples from reconditioned lots. These are taken from a lot of goods which has been seized and then reconditioned to bring it into compliance with the law. The sample is taken so that we can determine if the reconditioning were done in a satisfactory manner. These samples are usually not sealed.

3. General information. Such samples are collected to provide information not related to a particular case. They may be collected prior to initiating a regulatory program. Samples collected for laboratory use in the development of analytical methods fall in this category.

4. Survey samples. Market surveys are made in order to determine what the industry practice is with regard to the composition of a product, or what type of labeling is being used. These samples may be used to determine if there be a regulatory program needed for the product, and they are useful in planning enforcement work. Ordinarily, they are not used in specific legal actions.

5. Complaint samples. During the investigation of consumer complaints, samples of the product complained of are obtained. If the article be not of interstate origin, or if the complaint does not reflect a serious violation of the law, the FDA designates the samples as INV. Interstate products involved in injuries or serious violations are considered as official samples and are documented whenever possible.

Food Standards Samples. In establishing the standard for a food, evidence about the composition and labeling of various brands of that food is often introduced into the hearing held for the standard. This evidence is based on samples collected in factories or on the market. Since food standard hearings are conducted somewhat like courts, the information about the samples is treated just like court evidence. Food standard samples are handled in the same manner as official samples. They are sealed, and their integrity maintained. The purpose of food standard samples is distinctive, and they are considered to be a separate type.

Post-Seizure Samples. The federal government seizes materials only after it proves them to be in violation of the law. The state, however, can embargo materials on suspicion of violation. Lots of goods in violation are placed under seizure by the federal government and put in the custody of the United States Marshall. Where the state has jurisdiction, the materials are placed under an embargo, but remain in the possession of the owner. The claimant or the government may wish to collect samples after the goods are placed under seizure or under embargo. A claimant may wish to perform his own examination of the materials so that he can decide on a course of action to follow with regard to the seized or embargoed materials. The government may wish to do more analytical work in connection with the litigation over the seizure or the embargo. If the federal government or claimant wishes to take a sample of the federally seized goods, this can only be done with a court order. The state, however, by the very nature of its police power, can take a sample for itself or allow the owner to take a sample

from state embargoed goods after issuing a release notice to the owner for the material taken. If the claimant does initiate a request for a sample, it is the practice of the government to collect an equal and like sample. The integrity of these samples must be maintained and they are sealed, since they may be involved in a court action.

Import Samples. These are samples taken from goods offered for entry into the United States. They are examined to determine if entry into this country will be permitted. If the goods be entered, and a sample be taken from them at some later date, the sample is of the official type, just as if the goods had moved in interstate commerce.

Regulation -a-

1. "When any officer or employee of the Agency collects a sample of a food, drug, or cosmetic for analysis under the Act, the sample shall be designated as an official sample if records or other evidence be obtained by him or any other officer or employee of the Agency indicating that the shipment or other lot of the article from which such sample was collected was introduced or delivered for introduction into interstate commerce, or was in or was received in interstate commerce, or was manufactured within a Territory. Only samples so designated by an officer or employee of the Agency shall be considered to be official samples.

2. "For the purpose of determining whether or not a sample is collected for analysis, the term "analysis" includes examinations and tests.

3. "The owner of a food, drug, or cosmetic of which an official sample is collected is the person who owns the shipment or other lot of the article from which the sample is collected."

Regulation -b-

"When an officer or employee of the Agency collects an official sample of a food, drug, or cosmetic for analysis under the Act, he shall collect at least twice the quantity estimated by him to be sufficient for analysis, unless

1. "The amount of the article available and reasonably accessible for sampling be less than twice the quantity so estimated.

2. "The cost of twice the quantity so estimated exceeds $10.

3. "The article be perishable.

4. "The sample be collected from a shipment or other lot which is being imported or offered for import into the United States.

5. "The sample be collected from a person named on the label of the article, or his agent, and such person is also the owner of the article.

6. "The sample is collected from the owner of the article, or his agent, and such article bears no label, or if it bears a label, no person is named thereon; or

7. "The analysis consists principally of rapid analytical procedures, organoleptic exam-

ination, or other field inspection examination or tests, made at the place where the sample is connected or in a mobile or temporary laboratory.

"In addition to the quantity of sample prescribed above, the officer or employee shall if practicable, collect as part of the sample such further amount of the article as he estimates to be sufficient for use as exhibited in the trial of any case that may arise under the Act based on the sample." (Section 702 b)

"For the purpose of enforcing the provisions of this Act, carriers engaged in interstate commerce, and persons receiving food, drugs, devices, or cosmetics in interstate commerce or holding such articles so received, shall upon the request of an officer or employee duly designated by the Administrator permit such officer or employee, at reasonable times, to have access to and to copy all records showing the movement in interstate commerce of any food, drug, device, or cosmetic, or the holding thereof during or after such movement, and the quantity, shipper, and consignee thereof; and it shall be unlawful for any such carrier or person to fail to permit such access to and copying of any such record so requested when such request is accompanied by a statement in writing specifying the nature of kind of food, drug, device, or cosmetic to which such request relates; PROVIDED, That evidence obtained under this section shall not be used in a criminal prosecution of the persons from whom obtained; PROVIDED FURTHER, That carriers shall not be subject to the other provisions of this Act by reason of their receipt, carriage, holding or delivery of food, drugs, devices, or cosmetics in the usual course of business as carriers." (Section 703)

Enforcement

"Any article of food, drug, device, or cosmetic that is adulterated or misbranded when introduced into or while in interstate commerce, or which may not. . . be introduced into interstate commerce, shall be liable to be proceeded against while in interstate commerce, or at any time thereafter on libel of information and condemned in any district court of the United States within the jurisdiction of which the article is found. . .

"The court at any time after seizure up to a reasonable time before trial shall by order allow any party to a condemnation proceeding, his attorney or agent, to obtain a representative sample of the article seized, and as regards fresh fruit or fresh vegetables, a true copy of the analysis on which the proceeding is based and the identifying marks or numbers, if any, of the packages from which the samples analyzed were obtained.

"When a decree of condemnation is entered against the article, court costs and fees, and storage and other proper expenses, shall be awarded against the person, if any, intervening as claimant of the article."

"Any food, drug, device, or cosmetic condemned under this section shall, after entry of the decree, be disposed of by destruction or sale as the court may, in accordance with the provisions of this section, direct and the proceeds thereof, if sold, less the legal costs and charges, shall be paid into the Treasury of the United States; but such article shall not be sold under such decree contrary to the provisions of this Act or the laws of the jurisdiction in which sold: PROVIDED, That after entry of the decree and the payment of the costs of such proceedings and the execution of a good and sufficient bond conditioned that such article shall not be sold or disposed of contrary to the provisions of this Act or the laws of any State or Territory in which sold, the court may by order direct that such article be delivered to the owner thereof to be destroyed or brought into compliance with the provisions of this Act under the supervision of an officer or employee duly designated by the Administrator, and the expenses of such supervision shall be paid by person obtaining release of the article under bond. Any article condemned by reason of its being an article which may not be introduced into interstate commerce, shall be disposed of by destruction." (Section 304)

"The district courts of the United States and the United States courts of the Territories shall have jurisdiction, for cause shown, and subject to the provisions of section 17 (relating to notice to opposite party) of the Act entitled "An Act to supplement existing laws against unlawful re-

straints and monopolies, and for other purposes," approved October 15, 1914, as amended (U.S.C., 1934 ed., title 28, 281,) to restrain violations" (related to adulterating and misbranding, defacing labels, introducing new drugs for which application is not filed with the Administrator.)

"In case of violation of an injunction or restraining order issued under this section, which also constitutes a violation of this Act, trial shall be by the court, or upon demand of the accused, by a jury. Such trial shall be conducted in accordance with the practice and procedure applicable in the case of proceedings subject to the provisions of section 22 of Act of October 15, 1914, as amended (U.S.C., 1934 ed., title 28, sec. 387)." (Section 302 a., b.)

Hearings

"Before any violation of this Act is reported by the Administrator to any United States attorney for institution of a criminal proceeding the person against whom such proceeding is contemplated shall be given appropriate notice and an opportunity to present his views, either orally or in writing, with regard to such contemplated proceeding." (Section 305)

In Section 404 b., of the Federal Food, Drug and Cosmetic Act, already quoted in the foregoing, the holder of a suspended permit is given the right to a prompt hearing at any time by the Administrator for the purpose of applying for reinstatement.

"The Administrator, on his own initiative or upon an application of any interested industry or substantial portion thereof stating reasonable grounds therefor, shall hold a public hearing upon a proposal to issue, amend, or repeal any regulation contemplated by any of the following sections of this Act."

Deficiencies in the Act.

The quotations presented above from the Federal Food, Drug, and Cosmetic Act represent the general important features of regulative administration that are considered necessary in an American system of food, drug, and cosmetic control. There are, however, certain deficiencies in the Act which hold back its efficient execution. To be a better law, this Act should provide that:

1) Only those drugs whose effective physiological action is beyond any question for the purpose that it be pretended should be contained in proprietary preparations except in the case of vehicular substances.

2) When a violation is suspected, there should be provisions for rapid procedure in banning the material under suspicion from commerce, instead of requiring the proof of violation before acting.

3) Adequate system of penalties should be designated for violations so that punishment may not encourage the continued repetition of similar violations.

4) A method of obtaining quick decisions from the courts be instituted to frustrate the dilatory trickery of long drawn out litigation. Consideration should be given to empowering administrative bodies with judicial authority to carry out the task of rapid decisions for violations.

The Federal government leaves provisions dealing with the dispensing of drugs to state and local government where it may be more effectively handled. Therefore State and local laws should provide that dangerous drugs be sold only by physicians prescription. This is one of the truly important administrative problems in public health.

There are literally thousands of proprietary products on the market whose usefulness in treatment, prophylaxis, and prevention of diseases is either outright negative or of dubious effectiveness. It is the duty of the sanitarian to acquaint himself with this problem in order to aid the health officer where ever possible to eliminate the hazards attendant in the malpractice of selling drugs to the lay population. The sanitarian will not be able to determine the usefulness or uselessness of drugs. That he must leave to the discretion of the health officer. But he could be of great aid to his health officer by inspecting the proprietary products sold in general stores or any other non-pharmaceutical places of business, to ferret out products containing dangerous drugs which should not be sold without a physician's prescription. The laws of the various states of our country differ from place to place concerning the sale of such products. The sanitarian will need to acquaint himself with the specific laws in his locality concerning such drugs.

Most drugs which are beneficial in treatment of disease are poisons. This fact must be emphasized over and over again lest its importance be dulled in the humdrum of routine. A drug to be effective must be given in certain quantity doses. Many drugs are toxic or close to toxic when taken in therapeutic quantities, and therefore should be taken only by direction of and under the supervision of a physician who knows why the drug is given, its physiological effect on the body, and how to counteract its poisonous character. It is, of course, possible to put such small quantities of a drug into a prescription, that it neither poisons, nor has any therapeutic influence on the patient, and therefore the intake of such drugs is quite useless and its sale actually fraudulent. There are certain types of drugs which although taken in small quantities may accumulate in the body and eventually produce poisoning. Therefore it is dangerous to sell indiscriminately such medicines which contain even minute doses of certain types of drugs. Then, again, there are many drugs being sold to the public which contain no effective therapeutic agents whatsoever. In such cases the public is not injured physiologically, but from all evidence it is mulct of hundreds of millions of dollars each year by such fraudulent means.

No matter how this problem is approached, one can come to only one conclusion: For the best protection of the public the overwhelming majority of drugs sold to the laymen should be done so only on presentation of a physician's prescription.

No State laws nor Federal laws relative to the sale of drugs, really and truly are completely protective to the public. There are always loopholes allowing for the defrauding or the placing in jeopardy of the public.

The provisions in the Federal law for export foods, drugs, and cosmetics are dangerous to people in foreign countries, although they adhere strictly to the letter of legality: "A food, drug, device, or cosmetic intended for export shall not be deemed to be adulterated or misbranded under this Act if it (1) accords to the specifications of the foreign purchase, (2) is not in conflict with the laws of the country to which it is intended for export, and (3) is labeled on the outside of the shipping package to show that it is intended for export." (Section 801 d.)

This provision is flexible enough to allow the commitment of all degrees of crimes by the unscrupulous. No country should allow itself to be an accessory to a crime even if it be committed within the strict limits of legality. This should become a problem for the United Nations.

The penalties which the law provides against violators are hard and stringent only for the small operator, but scarcely ruffle the hair of a large operator who is able to absorb large fines as a routine matter and continue to violate the laws perennially.

Among the most important factors responsible for the inefficiencies of our food, drug, and cosmetic laws is the pressure exerted by powerful lobbies upon the various levels of government. The addition of provisions as discussed above would greatly restrict the production, sale, and export of thousands of useless or dangerous products to the detriment of the unscrupulous but to the greater welfare of our people both physically and economically.

Protective Aspect of the Act.

The Federal Food, Drug and Cosmetic Act is designed for the protection of public health, within the limits already discussed, and it also serves to protect the physician from unethical practices of irresponsible drug manufacturers. Features of the Act pertaining to drugs which are of particular interest to the health worker are:

1. It brings under governmental control (within certain limits) drugs used in the diagnosis of disease and drugs intended to affect the structure or any function of the body.

2. It prohibits traffic in drugs and devices which are dangerous to health under conditions of use prescribed in the labeling.

3. It prohibits traffic in new drugs unless such drugs have been adequately tested to show that they are safe for use under conditions of use prescribed in their labeling. It authorized exemption from this requirement of drugs intended solely for investigational use by qualified scientific experts.

4. It requires drugs intended for use by man to bear labels warning against habit formation if they contain any of a list of narcotic or hypnotic habit forming substances, or any derivative of any such substance which possesses the same properties.

5. It requires the labels of non-official drugs to have listed upon them the names of the active ingredients and in addition to show the quantity or proportion of certain specified ingredients.

6. It requires the labeling of drugs and devices to bear warnings against use in such conditions where the drug is dangerous, or by children when it is a hazard to their health, or against unsafe dosage or methods or duration of administration or application, in such a manner and form as are necessary for the protection of the user.

7. It requires labels of official drugs to reveal any difference of strength, quantity, or purity from the official standards.

8. It requires official drugs to be packaged and labeled as prescribed by the United States Pharmacopeia, National Formulary, and the Homeopathic Pharmacopeia.

9. It declares non-official drugs illegal if the standard of strength thereof differs from, or the purity or quality falls below, the standard claimed.

10. It requires that antiseptics possess germicidal power.

An "Official" drug in the United States is one which is included either in the United States Pharmacopeia (U.S.P.), the National Formulary (N.F.) or the Homeopathic Pharmacopeia.

Administration of Regulatory Procedure.

The administrative and legal procedure with which a sanitarian must be acquainted in order to fully understand his position in a food and drug control program varies from state to state. The administration of such a program may be vested in the State health department, the State department of agriculture or in a separate bureau created for that purpose. For the country as a whole, approximately a dozen separate types of State agencies either singly or jointly participate in some phase of the State's food and drug activities. In 3 States, 5 separate agencies are identified with food and drug control. The health and agriculture departments are the agencies which most usually participate in food and drug control. The health department participates (1950) in all States, the agriculture department in all but 8 States. The sanitarians in each State must study the laws and regulations pertaining to his own locality lest he complicate his position or that of his directing officer. He must also study the federal laws and regulations and those of other states with progressive programs so that he may have a comprehensive outlook on the whole problem. In order to give a picture of the functioning of such a program from the point of view of enforcement, the procedures practiced in the State of Louisiana will be described.

Louisiana may well be taken as an adequate example for illustrating regulatory procedure since it has a fine set of laws and administrative procedures, and since practically all food and drug control work is under the jurisdiction of the health department.

The institution for criminal proceedings will be discussed from the general state and local aspects and also as practiced by the Federal Food and Drug Administration.

Application for Permits. (Fig. 3)

In Louisiana all food establishments operate under the permit system. The Louisiana State Food, Drugs and Cosmetic Act, Section 7 (b) states: "The President (of Board of Health) is authorized to suspend immediately upon notice any permit issued under authority of this section if it is found that any of the conditions of the permit have been violated. The holder of a permit so suspended shall be privileged at any time to apply for the reinstatement of such permit, and the Board shall immediately after prompt hearing and an inspection of establishment, reinstate such permit if it is found that adequate measures have been taken to comply with and maintain the conditions of permit, as originally issued or as amended."

The proprietor of any food establishment obtains an "Application for Permit" by applying to the local or State Health Department. The application must be correctly filled out and returned to the local health department if the establishment operates at retail, and to the State Health Department if not at retail.

On receipt of such application, the Department will determine whether an inspection has been made of the business, and whether this inspection shows that all requirements of the laws and regulations have been observed. If all requirements have been met, the applicant is granted a "Permit to Operate" (Fig. 4). Only after receiving such a permit is the business legally allowed to operate. Every "Permit to Operate" must be renewed each year. The "Permit to Operate" can be revoked at any time that a violation of the laws, regulations or ordinances be found.

Registration and Collection of Fees.

The Board of Health is authorized "to require all manufacturers, packers, or proprietors of processed foods, proprietary or patent medicines, prophylactic devices, and cosmetics, in package form, to register each separate and distinct product annually with the Board and to supply this Board with a sample of each such product upon request." (Act 142 of 1936).

Anyone who fails to register each product or to re-register such product each year "with the Board shall cause the sale of such product to be stopped and shall subject such article to seizure and condemnation."

"Application for Registration" (Fig. 5) form must be correctly filled out and submitted with list and labels. Also submitted at the same time should be a check, draft, or money order as payment of registration fee.

No registration of products will be granted unless the above terms be correctly executed. A copy of the sanitarian's report should be sent to the central office of the State Health Department. If the Health Department wishes to investigate or has any reason to suspect the quality of a product, a sample may be requested. If, on examination, the product be found to be in violation of the law, it is subject to seizure and destruction even though it has been registered.

When manufacturers, packers, or proprietors of products furnish evidence that such products have been registered with the United States Government, and that such products are produced under the supervision of and have not been disapproved by the United States Governmen such registration will be accepted, without the furnishing of labels or samples of such products.

On receipt of the application, fees, and labels, and if all be in order, a printed "Certificate of Registration" (Fig. 6) is sent out. If, for any reason, the application be not in order, the Department acknowledges receipt of the application, fees, and labels, and advises that the registration certificate will be sent out when everything is in order.

Any infraction of the sanitary laws at any time may subject the registered products to regulatory action, either through seizure and destruction of the products, or injunction against the party responsible for their production, distribution or sale.

Procedure for Seizure of Foods and Drugs.

1. Inspection. An inspection in accordance with the regular routine should first be made, and an official inspection sheet filled out and correctly signed.

2. Temporary Seizure. If any of the products be found to be of such inferior quality as to be in violation of the health laws, sanitary code, health regulations or ordinances, or to have been processed, packed, labelled, stored or in any way handled in violation of the aforesaid laws, an "Official Notice of Seizure" (Figure 8) form should be filled out, signed and delivered, temporarily immobilizing the use, sale and transport of the product.

APPLICATION FOR PERMIT
LHS 31 REV 10 67

LOUISIANA STATE DEPARTMENT OF HEALTH

TOWN OR PARISH | DATE

Application is hereby made for a permit to operate By this application it is agreed that the establishment will comply with the provisions of the State Sanitary Code applicable to this type of establishment It is further agreed that said establishment shall be open to inspection by the State Department of Health

Before Filling This Application See Other Side

NAME OF BUSINESS OR FIRM | CITY OR TOWN | PARISH

STREET AND NUMBER | SIGNATURE OF PROPRIETOR OR MANAGER

Figure 3

INDICATE CLASS OF BUSINESS, AS ☒

Retail establishments should forward this application directly to the Parish Health Unit.

- ☐ Itinerant Food Handler
- ☐ Snowball Vendor
- ☐ Dairy Farm
- ☐ Milk Pasteurization Plant
- ☐ Creamery
- ☐ Milk Depot
- ☐ Ice Cream Parlor
- ☐ Lodging House
- ☐ Restaurant
- ☐ Soft Drink Stand
- ☐ Boarding House
- ☐ Coffee or Lunch Stand
- ☐ Delicatessen
- ☐ Fruit or Vegetable Market
- ☐ Grocery
- ☐ Hotel
- ☐ Tourist Camp
- ☐ Meat or Fish Market
- ☐ Soda Fountain
- ☐ Swimming Pool

Wholesale establishments forward this application to:
STATE DEPARTMENT OF HEALTH
P O Box 60630
New Orleans, Louisiana

- ☐ Bakery
- ☐ Cold Storage
- ☐ Confectionery (mfg.)
- ☐ Potato Chips
- ☐ Coffee Plant
- ☐ Winery
- ☐ Tamales
- ☐ Quick Freezing Plant
- ☐ Cheese
- ☐ Butter
- ☐ Packing Plant
- ☐ Sausage Manufacturer
- ☐ Preserves
- ☐ Process Oil Plant
- ☐ Ice Manufacturing Plant
- ☐ Ice Packaging Plant
- ☐ Canning Plant
- ☐ Ice Cream Factory
- ☐ Macaroni or Spaghetti Factory
- ☐ Slaughter House
- ☐ Syrup Mill
- ☐ Sugar Mill
- ☐ Flour Mill
- ☐ Rice Mill
- ☐ Pepper Plant
- ☐ Pickle Plant
- ☐ Cold Pack
- ☐ Condiments
- ☐ Alcoholic Beverage Plant
- ☐ Nut Processing Plant

Figure 3 (Reverse Side)

APPLICATION FOR REGISTRATION
FD 9

LOUISIANA STATE BOARD OF HEALTH
DIVISION OF FOOD AND DRUGS
Louisiana State Office Building
P O BOX 60630 NEW ORLEANS 60, LOUISIANA

Application for registration should be made in the name of the firm appearing on the label of product Labels for new products and recently revised labels must accompany application

Previous Registration Number | FOODS | DRUGS | COSMETICS | PROPHYLACTICS | DATE

NAME OF BUSINESS

SIGNATURE OF PROPRIETOR OR EXECUTIVE OFFICER | TITLE

BUSINESS ADDRESS

TOWN AND STATE

Application is hereby made for registration of the following named products, in accordance with the requirements of the Louisiana State Food, Drugs and Cosmetic Law, Title 40, Chapter 4, Part 1 La Revised Statutes 1950 as amended.

If additional space is needed attach a plain white paper listing products for registration and any other information A printed catalog may be submitted in lieu of a typewritten list

The examination and investigation fee is $2 50 for each separate and distinct product annually, with a maximum fee of $10 00 to any one manufacturer, packer or distributor

A check, draft or money order, payable to the Louisiana State Board of Health must accompany this application to cover the required fee | AMOUNT ENCLOSED $

TO BE RETURNED TO STATE BOARD OF HEALTH WITH LABEL AND FEE

Figure 5

PERMIT MUST BE PUBLICLY DISPLAYED AT ALL TIMES, AND USED ONLY IN PLACE OF BUSINESS INDICATED HEREON

LOUISIANA STATE DEPARTMENT OF HEALTH
FOOD AND DRUG DIVISION
PERMIT TO OPERATE

Permit No _____
Issuance Date _____
Expiration Date _____

Name _____
Address _____
Nature of Operation _____

This is to certify that the operator named above has duly registered with the Louisiana State Department of Health according to the Sanitary Code of Louisiana, and is hereby given permission to operate

This permit is issued in consideration of the operator's agreement to allow inspections of the premises by the State Health Department and fully complying with the rules and regulations of the State Sanitary Code This permit may be revoked for failure to comply with the foregoing agreements

HEAD FOOD AND DRUG DIVISION | STATE HEALTH OFFICER

FD 24 (R 11-67)

Figure 4

LOUISIANA STATE DEPARTMENT OF HEALTH
P O BOX 60630
Louisiana State Office Building
NEW ORLEANS, LA 70160

CERTIFICATE OF REGISTRATION
F. D. & A.
REGISTRATION NO | EXPIRATION DATE | TODAY'S DATE

YOU ARE ADVISED THAT THE PRODUCT(S) LISTED BELOW FOR WHICH YOU MADE APPLICATION FOR REGISTRATION IS/ARE REGISTERED

PRODUCT(S)

This registration does not deter the **State Board of Health** from instituting action should subsequent examination show these products to be adulterated and/or misbranded within the meaning of the State Food, Drug and Cosmetics Law

TO

CERTIFIED BY HEAD FOOD AND DRUG DIVISION

STATE HEALTH OFFICER
A 4990

ORIGINAL

Figure 6

3. Investigational Sampling. After the goods have been placed under seizure, one investigational sample should be collected. With canned or packaged goods, this investigational sample should consist of at least 3 cans or unit packages; in case of bulk goods, at least 3 pints of liquid or semi-liquid products, and at least 3 pounds of dry products. These bulk samples should be taken from at least 3 different barrels, boxes, bags, crates, or other containers. Fruit or vegetables suspected of bearing excess residue should be sampled in accordance with the procedures outlined latterly.

4. Identification of Samples. At time of collection of samples, each sample should be labelled with an official identification seal sticker which is attached to Sample Collection Data Sheet (Fig. 7) correctly filled out. In case of hermetically sealed containers, such as canned goods, it is not necessary to attach the sticker, although each can should be identified by scratching, with some sharp instrument, the sample number, date, and inspector's name or initials on one end of the can. The cans may be wrapped in paper, placed in paper bags or otherwise packaged so that the sticker may be effectively placed to seal the package. "Seals" should not be attached to any bottle, package, can or other container so as to cover any portion of the label.

A "Sample Collection Data Sheet" (Fig. 7) should be filled out for each sample collected. This data sheet should be attached to or enclosed with the sample so that both samples and data arrive together. A "sample" is considered as all the units or subdivisions of the same material, collected at one time from a lot or shipment of goods being offered in commerce.

The samples are sent to the head of the Food and Drug Division.

5. Report from Food and Drug Division. Wait for report from Food and Drug Division, and proceed further, only in accordance with the order given by that Division.

6. Disposal of Seized Material.

a) If material should be seized and destroyed, proceed as directed in report from Food and Drug Division. No material should be destroyed without official notice from the office of the State Health Department, and the issuance of seizure and destroy forms (Figures 8 and 9).

b) If material should be released, do so by filling out "Official Release Notice" form (Figure 10).

No seizure should ever be attempted by the sanitarian without first conferring with the Director of the local Health Department by whom the seizure proceedings must be initiated.

Enough samples should be sent to Food and Drug Division to represent an adequate sample of the materials. Samples must be paid for by the Health Department only if an excessive quantity be demanded. The Louisiana State Food, Drugs, and Cosmetic Act authorizes the Board of Health " to require all manufacturers, packers, or proprietors of processed foods . . . to supply their Board with a sample of each product upon request."

If milk be seized, the same procedure as above outlined must be followed. The seized milk must be put in cool storage. The storage fees must be paid for by the Department of Health. If the dairy man requires payment for samples of milk collected, he is in the right if the sample exceeds one pint.

Institution of Criminal Proceedings.

Usually state laws require or imply that before court action is taken, the accused should be accorded a hearing by the board of health. It is, in fact, always wise to hold such a hearing, not only in justice to the defendent, but also because it brings out his defense, which is sometimes useful to know in advance. The desirability of a hearing does not, of course, preclude summary action without it if the protection of the public health demands such procedure.

LOUISIANA STATE BOARD OF HEALTH
SAMPLE COLLECTION DATA SHEET

E 7218

Sample of _____

Label _____
(NAME OF PRODUCT, BRAND, CODES, WAREHOUSE NUMBERS, ETC.)

Amount of sample _____ Amount of material left _____

Manufactured or Packed by _____ Address _____
(LEAVE BLANK IF UNKNOWN)

Received by Dealer from _____ Address _____

Dealer _____ Address _____

Collected on _____ at _____ A.M. P.M. City _____ Parish _____

Length of time in stock _____

Reasons for collection and/or test desired _____

Were goods seized _____ (YES) _____ (NO) Amount seized _____

Remarks _____

SIGNATURE OF OWNER OR AGENT

TO BE FILLED OUT IN TRIPLICATE

SIGNATURE OF SANITARIAN

12-60 200 Blks. F. D. 3

La. State Board of Health
Div. Food & Drug
I. S. E 7218
Date _____
Insp. _____

La. State Board of Health
Div. Food & Drug
I. S. E 7218
Date _____
Insp. _____

La. State Board of Health
Div. Food & Drug
I. S. E 7218
Date _____
Insp. _____

Figure 7

LOUISIANA STATE BOARD OF HEALTH

OFFICIAL NOTICE OF SEIZURE
FD 21

NAME OF ESTABLISHMENT WHERE SEIZED | OWNER OR OFFICIAL OF ESTABLISHMENT

TOWN | STREET | PARISH

You are hereby notified that the following material or materials are placed under seizure being suspected in violation of the State Food, Drug and Cosmetic Law and Regulations promulgated thereunder, and are not to be moved for sale or sold until released by written order from the Louisiana State Board of Health, or by order of a Court of competent jurisdiction.

LOCATION OF MATERIAL

SAMPLE TAKEN | I S NUMBER

LOUISIANA STATE BOARD OF HEALTH

DATE

☐ Food and Drug Control Officer
☐ Sanitarian

SIGNATURE OF RECIPIENT

By authority of R.S. 40.632 & R.S. 40.633 of 1950 of the State Food, Drug, and Cosmetic Law.

STATE CAUSE FOR SEIZURE

OWNER OF SEIZED MATERIAL

TOWN | STREET | PARISH

Figure 8

REPORT ON DESTRUCTION OF MATERIAL
FD 11

LOUISIANA STATE DEPARTMENT OF HEALTH
DIVISION OF FOOD AND DRUGS

NAME OF FIRM | DATE

ADDRESS | PARISH

MATERIAL LOCATED AT

PREVIOUSLY SEIZED ☐ Yes ☐ No | DATE

The Following Material Has Been Rendered Unfit for Consumption

METHOD OF DESTRUCTION OR DENATURING

WHOLESALE VALUE OF MATERIAL (WHERE AVAILABLE)
$

RECIPIENT

☐ F & D CONTROL OFFICER ☐ SANITARIAN

SIGNATURE DATE

SIGNATURE DATE

Figure 9

OFFICIAL RELEASE NOTICE
FD-22

LOUISIANA STATE BOARD OF HEALTH
DIVISION OF FOODS AND DRUGS

NAME OF BUSINESS | OWNER OR OFFICIAL

ADDRESS | CITY | PARISH

THE FOLLOWING MATERIAL PLACED UNDER SEIZURE ON

19 AT

Due to violation or suspected violation of the State Food, Drug and Cosmetic Law (Title 40, Chapter 4, Part 1, Louisiana Revised Statutes of 1950 as amended), is hereby released as provided for by Section 634 of the law, to be disposed of as ordered:

METHOD OF DISPOSAL

DATE | SANITARIAN OR F & D CONTROL OFFICER

Figure 10

Pre-hearing Inspection. Before a hearing is held, the health officer must have evidence that a violation has been committed. Therefore an inspection in accordance with the regular routine should first be made, and an official inspection sheet filled out and correctly signed. The proprietor is notified that the corrections must be made within a reasonable length of time (usually 10 days; less than 10 days for critical violations.)

Being "reasonable" in public health procedure is one of the most important factors considered by the court in prosecuting cases of violation against the public health. This should not be interpreted to mean being indecisive or slow in implementing the provisions of the law, but rather in being precise, alert, and ready to act without prejudice or discrimination, and being able to evaluate the length of time to be allowed for the correction of a particular condition. Only in emergency or critical situations is it reasonable for a health officer to institute criminal or injunction proceedings after the first inspection.

At the end of the period allowed after the first inspection to make necessary corrections, a second inspection is made and an inspection form filled out. If no satisfactory progress be made to correct the violation, the sanitarian notifies the health officer, who in turn notifies the proprietor to appear at the health department office for a hearing at a definitely designated time. This notification is sent by registered mail, so that the proprietor may have no alibi if the case happens to go further to the courts. If the violation be of a nature needing immediate attention, the sanitarian may in person deliver the notification to the proprietor to appear for hearing before the health officer.

When the violation is concerned with a product rather than a sanitary facility, technique, or permit, the pre-hearing inspection should involve the collection of a sample for laboratory examination. The sample should be so collected and examined that no step from the collection to the conclusion of the examination should vitiate the validity of the sample. If the sample be found to be in violation of the law, the offender is notified to appear at a hearing immediately. If the violation be of a hazardous nature, the product is immediately placed under seizure before a hearing.

The Hearing. The health officer must inquire why correction was not made, and if the reasons given by proprietor be justifiable, and assurances of willingness be shown that the correction will be made as soon as possible, the health officer will allow a reasonably extended time for the correction of violations. If the proprietor be uncooperative and gives unjustifiable excuses, or if no excuses be made, then the health officer should consider filing an affidavit for prosecution. If the proprietor does not appear at the hearing nor informs the health officer beforehand of any

adequate reason for not appearing, consideration should be given to filing charges.

Post-hearing Inspection. If at the time of the hearing additional time be allowed, then the sanitarian should report at the expiration of the time whether or not the corrections have been made; and if such corrections have still not been made, then consideration should be given for filing criminal or injunction proceedings.

Post-hearing Procedure for Court Action. The essential fact to remember in taking offenders to court is to have a thoroughly prepared case. It is necessary, in order to be successful, to be able to prove the case conclusively.

In preparing the case, each chapter and article of the law is quoted for each type of violation. The violation of local health ordinances or regulations usually constitute a misdemeanor, though in some instances they might be of more serious criminal nature. In any event the action is a criminal one and is brought before a criminal court, usually an inferior one, as a police court or magistrate. The municipal attorney, or sometimes the health officer himself, fills out a complaint form and turns it over to the magistrate. The information given must be precise and complete and where an order has been violated must give its terms or substance. The magistrate issues a summons, which a constable or officer serves on the accused person who is ordered by it to appear in court on a certain day and hour. At the stated time a hearing is held, usually without a jury, and the issue is decided after both parties and their witnesses have been heard. The accused may, of course, be represented by an attorney.

Under some state laws, a local board of health itself may issue a warrant for an offender against the health ordinances or regulations, and summon him to appear before the board for a hearing. It may even sometimes impose a fine upon him, if he be found guilty; but if he refuses to pay, he must be sued for the amount of the fine.

The magistrates' courts may also be used for preliminary hearings in more serious criminal cases, the magistrate or justice of the peace merely conducting a hearing to determine whether the accused shall be held for action by a grand jury or other indicting agency. The ultimate guilt of the person is not decided, as that is left for a proceeding in a higher court having criminal jurisdiction.

Ordinarily, an appeal by the defendent is allowed from the decision of a justice of the peace, magistrate, or police court, to the next highest of the state courts.

Violations of state health laws, sanitary codes, or regulations of the state board of health are generally brought in the first instance into one of the local state courts of general jurisdiction, namely, a district court, county court, court of common pleas, circuit court, superior court, o in the large cities, municipal or city court.

The Health Department makes no closures itself. Closures must be made through the court and carried out by the police authority. Although sanitarians or other representatives of the Health Department maybe empowered to make arrests under certain conditions, this duty is best delegated to the police authorities, since health work should wherever possible connote "service and education" rather than "force."

If proceedings be instituted against a violator of the law, and the court acts favorably to the Health Department, it does not mean that the place of business of the violator be immediately closed. In order to close an establishment it becomes necessary to institute injunction proceedings.

To institute injunction proceedings is a serious matter. In our democratic form of legal procedure, the injunction is a very severe measure to invoke. It should be used only in recalcitrant cases and emergencies.

In a great many instances an establishment may be closed by the owner or manager of his own accord if properly advised as to the unsanitary condition of his plant and the health hazard it is to the community. Particularly is this true if he be advised that if he does not close as the law

requires, it will be necessary to institute court action. Knowledge that the unfavorable publicity attendant with such action will hurt his business is a potent weapon.

Violations of the Federal Food and Drug Act are prosecuted in Federal Courts.* The initial step is for the federal agent, inspector or sanitarian, to collect samples of the suspected violation. This is forwarded to the proper station for analysis. The results of the analysis are sent by the station chief to his district chief with recommendations as to the proper action to be adopted. The district chief, if he approves the recommendation, instructs the station chief to cite the violator to a hearing at the station headquarters by a written notice. At the same time the district chief submits a statement of action taken to the chief of the Food and Drug Administration in Washington. The notice to the violator that a sample was taken and examined and appears to be adulterated or misbranded is accompanied with a charge sheet showing the provision of the Act under which the violation is alleged, supplemented if necessary for clarity, by a note specifying the respects in which the article seems to be in violation. Along with this information, the notice states that the person cited will be accorded an opportunity to present evidence, either oral or written, in person or by attorney, to show cause why the matter should not be referred to the Department of Justice for prosecution as a violation of the provisions of the Act, and that no party will be prosecuted if he can establish a valid guaranty.

There is no provision for compelling the presence of the party from whom the sample was received; if he voluntarily attends he is not in jeopardy; an adverse finding is not binding against him; and a decision in his favor is not an acquittal which prevents a subsequent hearing before the department, or a trial in court. The legal effect of the hearing is that it makes prosecution by the district attorney mandatory. In practice, however, the administrative hearing affords a real protection, for it is only rarely that a district attorney institutes prosecution for criminal penalties under the Food and Drugs Act otherwise than at the instance of the Department of Health, Education, and Welfare. Furthermore, the Department, by regulations issued under that Act, binds itself to give administrative hearings to all interested parties whenever criminal prosecution is contemplated. Hearings are held in the field stations, the presiding officer being either chief of the station or his assistant. If the parties cited request the transfer of the hearing to another station within the district, the request is usually granted provided the request be seasonably made and be based upon reasonable ground.

In the conduct of the hearings, the presentation of views are private and informal. The views presented are confined to matters relevant to the contemplated proceeding. Such views may be presented by letter or in person by the person to whom the notice was given, or by his representative.

The officer holding the hearing explains to the respondent the nature of the charges, and a full opportunity for discussion is given the latter. While the hearing is supposedly confined to questions of fact, since its purpose is to give those cited an opportunity to show cause why the matter should not be referred for prosecution, all statements offered in explanation of mitigation are reported. The presiding officer is not a lawyer, and if legal arguments be presented by counsel, they are usually permitted to go into the record for consideration by the Solicitor's Office. Rules of evidence are not followed and there is no right to cross-examination, nor are the statements made under oath. Despite the informality of the proceedings, a full record is kept in every instance where there is a likelihood that prosecution may follow. A copy of the record may be obtained by the respondent upon request therefor and the payment of the cost of its transcription.

At these proceedings, only general conclusions reached by the analyst and general statements as to why a product is considered adulterated or misbranded are disclosed. The parties cited may request a portion of the official sample. The Act permits "reasonable exceptions" and conditions to such requests.

After the hearing, facts developed by the Government investigation are considered by the station chief in the light of any representation the proposed defendant has made and a recommendation is made to the district chief as to whether prosecution should or should not follow. The district chief reviews the recommendation, endorses, modifies or revises it, and refers it to the Washington headquarters of the Food and Drug Administration, expressing his reasons for any

*The procedure for such prosecution is described in great detail in "The Law of Foods, Drugs, and Cosmetics," by H. A. Toulmin.

disagreement with the station chief.

Agreement with the disposition recommended by the station does not prevent the district chief from adding a memorandum containing further arguments or relevant facts when transmitting the case to Washington. When the recommendation is received in Washington, if technical questions be involved, it is referred to the technical unit within whose province it comes before referring the matter to the Office of the Chief. The review by the technical staff expert covers all the factors involved including the sufficiency of the analysis, the analytical evidence available either in the jacket of the case or elsewhere, additional determinations if needed, and the need for trade or expert witnesses in the event of contest in the courts. If the expert disagrees with the recommendation of the district chief, the matter is handled between the two until an agreement is reached. If agreement cannot be reached, the case is referred to the Chief or Assistant Chief of the Food and Drug Administration with a statement of all the facts for final decision. The office of the Chief reviews all recommendations from the standpoint of facts and administrative policy.

If the Food and Drug Administration recommends prosecution, the matter is referred to the Solicitor for review of the legal phases. If he disagrees with the recommendation of the Administration, he returns the paper for further consideration. But if the evidence as to jurisdiction and substantive guilt be found sufficient, the case is referred to the Department of Justice for prosecution. At any time after appearance before the station chief, the prospective defendant is given the opportunity, if he requests it, to appear before the superior officers of the Administration.

The dilatory character of the prosecuting procedure of the Federal Food, Drug, and Cosmetic Act is so tedious, that the Federal agents ask the State agencies, in many instances where state laws are better than Federal, to prosecute violations in their states in order to get prompt action.

Certification and Listing of Colors.

Since the certification and listing of coal-tar colors as practiced by the Federal Food and Drug Administration is the model generally followed in various states, and since practically all acceptable coal-tar colors that are being used in foods, drugs, and cosmetics find their way into interstate commerce and must therefore be certified and listed with the Federal government, the administration of regulatory procedure for coal-tar colors as practiced by the Federal Food and Drug Administration will be described herein.

Definitions:

1. Coal-tar Color means articles which are composed of or contain any substance derived from coal-tar, or any substance so related in its chemical structure to a constituent of coal-tar as to be capable of derivation from such constituent, and when added or applied to a food, drug, cosmetic, or the human body or any part thereof, are capable (alone or through reaction with other substance) of imparting color thereto.

2. Straight Color means a coal-tar color listed in the Federal Food, and Drug Administration regulations in Section 135.03, 135.04 or 135.05 and includes such impurities and substrata as are contained in such color.

3. Mixture means a coal-tar color made by mixing two or more straight colors, or one or more staight colors and one or more diluents.

4. Diluent means any component of a coal-tar color, except a straight color.

5. Pure Dye means the coal-tar dye contained in a coal-tar color, exclusive of any intermediate or other impurity, or of any diluent or substratum contained therein.

6. Substratum means the substance on which the pure dye in a lake is extended.

7. Batch means a quantity of coal-tar color which is set apart and held as a unit for the purpose of obtaining certification of such quantity.

8. Batch Number means the number assigned to a batch by the person who requests certification thereof.

9. Lot Number means an identifying number or symbol assigned to a batch by the Food and Drug Administration.

10. Externally Applied Drugs and Cosmetics means drugs and cosmetics which are applied only to external parts of the body and not to the lips or any body surface covered by mucous membrane.

11. The Color Additive Amendments Act of 1960 introduces and defines the term Color Additive, as a material which is a dye, pigment, or other substance made by a process of synthesis or similar artifice, or extracted, isolated, or otherwise derived, with or without intermediate or final change of identity, from a vegetable, animal, mineral , or other source, and when added or applied to a food, drug, or cosmetic, or to the human body or any part thereof, is capable (alone or through reaction with other substances) of imparting color thereto, except that such term does not include any material which is determined by regulation be used (or intended to be used) solely for a purpose or purpose other than coloring.

This law makes it the responsibility of the party desiring to use such color additive in food, drug, or cosmetics to present the scientific data proving the safety of its use under the conditions it is to be used. This reverses the placement of responsibility for proving the safety of a product from the governmental agency to the commercial producer.

Explanatory Data: Only coal-tar colors must be certified. Each individual batch must be certified. Vegetable, animal, or mineral colors do not require certification. A certified coal-tar is one which, upon investigation is found to be harmless and suitable for use in accordance to the prescribed standards of purity. When a certain type of coal-tar color is certified and listed in the coal-tar regulations, each succeeding batch of listed colors which are manufactured must be certified before it can legally be used in a food, drug or cosmetic. Batches of coal-tar colors may be certified for use in three ways, depending upon the nature of their use, i.e., whether they are to be used:

1. In foods, drugs and cosmetics (abbreviated as FD&C)
2. In drugs and cosmetics (abbreviated as D&C)
3. In drugs and cosmetics applied externally only (abbreviated as Ext. D&C)

The abbreviations are used in labelling.

The authorization for the certification of coal-tar colors must not be considered an authorization for the use of the coal-tar color in any article which is applied to the area of the eye. A coal-tar color used in any such article which is so applied shall be considered to be from a batch that has not been certified in accordance with the coal-tar regulations even though such color be from a batch that has been certified for other use. The term "area of the eye" means the area enclosed within the circumference of the supra-orbital ridge and the infra-orbital ridge, including the eyebrow, the skin below the eyebrow, the eyelids and the eyelashes, the conjunctival sac of the eye, the eyeball, and the soft tissue that lies within the perimeter of the infra-orbital ridge.

Certification of Antibiotics. Batches of drugs composed wholly or partly of antibiotics must be certified if such drug has the strength, quality, and purity as are necessary to adequately insure safety and efficiency of use, but shall not otherwise be certified. The date of expiration for each batch and tests and methods of assay to determine compliance with standards shall be prescribed. Exemption from certification is allowed for drugs which are to be stored, processed, labelled, or repacked at establishments other than those where manufactured, on condition that such drugs comply with all such requirements upon removal from such establishments, for drugs which conform to applicable standards of identity, quality, and purity and are intended for use in manufacturing other drugs, and for drugs which are intended solely for research in determining safety and efficiency of use.

Procedure for Admitting Colors to Listing. An application for the admission of a coal-tar color to listing must be accompanied by:

1. Full reports of investigations which are adequate to show whether or not such color is harmless and suitable for use in food, drugs, and cosmetics, or in drugs and cosmetics, or in externally applied drugs and cosmetics, as the case may be.

2. A full statement of the percentages and compositions of the pure dye and all intermediates and other impurities contained in such color.

3. A full statement showing the identity, purity, and quantity or proportion of each intermediate and other article used as a component of such color, and all steps in the process used for the manufacture of such color.

4. A full description of practical and accurate methods of analysis for the quantitive determination of the pure dye and of all intermediates and other impurities contained in such color.

5. A full description of practical and accurate methods for the identification of such dye in food, drugs, and cosmetics colored therewith, or in drugs and cosmetics colored therewith.

6. A five-pound sample of such color (unless the Food and Drug Administration authorizes or requires submission of other quantity suitable to the need for investigation) taken from a batch produced under practical manufacturing conditions, and accurately representative of such batch.

7. The advance deposit of $500 to cover fees for services provided attending the listing of a coal-tar dye. Any excess advance deposit will be returned to the applicant after the close of the investigation of the coal-tar.

If the administrator determines after such investigation as he considers to be necessary, that:

1. Such color be harmless and suitable for use in food, drugs, and cosmetics, or in drugs and cosmetics, or in externally applied drugs and cosmetics.

2. Practical and accurate methods of analysis exist for the quantitive determination of the pure dye and all intermediates and other impurities contained in such color.

3. Practical and accurate methods exist for the identification of such dye in food, drugs, and cosmetics colored therewith, or in drugs and cosmetics colored therewith, then, the Administrator, for the purpose of listing such color will proceed with a process of amending the list in the regulations so as to include the color.

If the administrator, after such investigation as he considers to be necessary, determines that such color does not comply with the requirements with respect to procedure for the purpose of listing such color, the administrator gives notice thereof to the applicant, stating the respects in which such color does not comply.

Procedure for Certification of Colors. If the Food and Drug Administration determines, after such investigation as it considers to be necessary, that:

1. The request for certification appears to contain no untrue statement of a material fact.

2. In case of a straight color, such color conforms to the specifications set forth in the regulations.

3. In case of a mixture containing a diluent, such diluent be harmless and suitable for use therein.

4. The batch covered by such request otherwise appears to comply with the regulations.

Then, the Administrator will issue to the person who submitted such request a certificate showing the lot number assigned to such batch and that such batch, subject to the terms, conditions, and restrictions prescribed in the regulations is a certified batch for use in food, drugs, and cosmetics, or for use only in drugs and cosmetics, or for use only in externally applied drugs and cosmetics as the case may be.

If the administrator determines, after such investigation as he considers to be necessary, that the request submitted, or the batch or coal-tar color covered by the request, does not comply with the requirements laid down for the issuance of a certificate, the administrator will refuse to certify such a batch and will give notice thereof to the person who submitted such request, stating the reasons for refusal.

Procedure for Requesting Certification of Coal-Tar Colors:

Straight Colors: Except in case of a request for repacking, a person who requests the certification of a batch of a straight color must submit as part of his request, statements showing:

1. Whether or not he manufactured such batch, and if he did not, the name and post office address of the manufacturer thereof.

2. The name of such color, as listed in the regulations, and the batch number and quantity of such batch.

3. In case of a lake, the process whereby such lake is made, including the name or names of the substrate present and the quantity thereof used for such batch.

Such request must be accompanied by a 1/4 pound sample taken from such batch and accurately representative thereof, and by the fee prescribed. Such person must submit such additional information and samples as the administrator may require for the purpose of determining whether or not such batch complies with the requirements laid down for issuance of a certificate.

Mixture: Except in the case of a request submitted for repacking, a person who requests certification of a batch of a mixture must submit as part of his request statements:

1. To the effect that he mixed such batch.

2. Showing the name of such mixture, and the batch number and quantity of such batch.

3. Showing the lot number of each coal-tar color used as an ingredient in mixing such batch, the quantity of such color so used, and that such color has not changed in composition in any manner whatever since certification, except by mixing into such batch.

4. Showing the name, quality, and quantity of each diluent used as an ingredient in mixing such batch.

5. In case such mixture contains a permitted diluent (resins, natural gum, pectin, or .1% sodium benzoate) only because such mixture is for use in coloring shell eggs or such diluent does not become a component of a food colored by such mixture, specifying the name of the food for which such mixture is used.

6. Describing fully the process of mixing, with special reference to the precautions taken to render such batch uniform in composition.

As for straight colors, a sample and fee must be submitted, except that for mixtures the sample should weigh 1/8 pound, but if the mixture contains 2% or less of a pure dye the sample should weigh 1/4 pound.

Repacks: A person who requests the certification of a batch made by repacking a coal-tar color from a batch previously certified under these regulations, must submit as part of his request statements:

1. To the effect that he made the batch on which he requests certification by repacking such color, and that such color has not changed in composition in any manner whatever since such previous certification.

2. Showing the lot number of such previously certified batch, the name of such repacked color, and the batch number and quantity of such repacked batch.

As for straight colors and mixtures, a sample must weigh 1/8 pound.

Naming of Colors and Labeling Requirements. According to the group in which colors are listed, they are prefexed: FD&C, D&C, or Ext. D&C.

The labelling requirements for each package of coal-tar color from a batch that has been certified are:

1. An accurate statement of the net contents of the package.
2. The name and place of business of manufacturer, packer, or distributor.

3. In the case of mixtures for food use, the name of the color components and that of each diluent contained in the mixture.
4. The name of the color.
5. The lot number of the batch.
6. The pure dye content of the color.
7. In the case of a color certified only for a limited use, a statement setting forth this limitation.

Packages of coal-tar colors shall be exempt from the label requirements relative to net content as follows:

1. Colors for food use containing less than 1/2 ounce avoirdupois or less than 1/2 fluid ounce or less than 6 units (if these units can be easily counted without opening the package), or if the label space be so limited that all required information cannot appear conspiciously.

2. Colors for drugs and cosmetics containing less than 1/4 ounce avoirdupois or less than 1/8 fluid ounce or less than 6 units (which can easily be counted without opening the package.)

Whenever an inspection is made of establishments manufacturing foods, drugs or cosmetics, where colorings are added, all colors should be checked for the certification number as given by the Federal Food and Drug Administration, and for generally correct labelling of the color. If no certification number be given, then the color should be regarded with suspicion and placed under seizure pending receipt of the certification number.

Uses and Misuses of Certified Colors. Certified food colors may be used in some classes of food and not in others.
1. They cannot be used in milk.
2. Yellow coloring must not be used in macaroni, mayonnaise or bakery products to make them simulate the presence of eggs.
3. Certified colors may be used in butter, ice cream and cheese without labelling the product.
4. Candies may contain certified colors but must be labelled.
5. Not only must meat not be colored to make it look red, but such materials as paprika, tomatoes, etc., must not be used to make it look red even when the meat is labelled.
6. No coal-tar color may be certified for use in any article to be applied to the area of the eye.

Other Federal Laws Relating to Food and Drugs.
Those administered by Department of Health, Education, and Welfare through:
The Federal Food and Drug Administration:

b. The Color Additive Amendments Act of 1960 gives the Secretary of the Department of Health, Education, and Welfare authority to declare, pursuant to studying the scientific data available, any color additive for food, drugs, or cosmetics as safe and suitable for the use or uses for which the particular color additive is listed, and to prescribe the conditions under which such color additive may be safely employed for such use or uses for which the particular color additive is listed, and to prescribe the conditions under which such color additive may be safely employed for such use of uses.

The Tea Act of 1883 as amended prohibits the importation into this country of tea that is inferior to standards of quality fixed by the administrator.

The Filled Milk Act of 1923 as amended 1935 defines the term "filled milk" and prohibits its shipment in interstate commerce. "Filled milk" is defined as any milk, cream, or skimmed milk, whether or not condensed, evaporated, concentrated, powdered, dried, or desiccated, to which has been added or which has been compounded with, any fat or oil other than milk fat, so that the resulting product is an imitation or semblance of the milk product mentioned. Similar laws are in force in 75% of the states in the United States.

The Federal Import Milk Act of 1927 prohibits the importation of any milk or cream into the United States unless the shipper has a valid permit. The purpose of the act is to promote the

dairy industry in the United States. According to this act, all milk and cream:

1) If raw, must come from healthy tuberculosis tested cattle.
2) Must be produced in a sanitary manner.
3) If raw milk, must contain not more than 300,000 bacteria per c.c.
4) If raw cream, must contain not more than 750,000 bacteria per c.c.
5) If pasteurized milk, must contain not more than 100,000 bacteria per c.c.
6) If pasteurized cream, must contain not more than 500,000 bacteria per c.c.
7) Must not exceed 50° F. in temperature.

The Federal Caustic Poison Act of 1927 is to safeguard the distribution and sale of certain dangerous caustic and corrosive acids, alkalies and other substances in interstate and foreign commerce.

a. The Federal Hazardous Substances Labeling Act of 1960 gives authority to the Secretary of the Department of Health, Education, and Welfare to declare any substance or mixture of substances introduced or intended for introduction into interstate commerce and which is intended or suitable for household use to be a hazardous substance if the Secretary finds such substance to be hazardous to the public under the conditions of its use.

The Public Health Service:

The Virus, Serum, and Antitoxin Act of 1902 regulates by license the importation, exportation and sale of all viruses, serums, toxins, and antitoxins to be used for the prevention and cure of diseases of man.

Those administered by the Department of Agriculture:

The Meat Inspection Act of 1907 as amended 1938 empowers the Secretary of Agriculture to have examined and inspected all cattle, swine, sheep, and goats before they are allowed to enter any slaughtering, packing, salting, rendering, or similar establishment for preparation for shipment in interstate commerce as articles of food. Post-mortem examination of all slaughtered animals and inspection of meat products are also provided for.

The Imported Meat Act of 1913 as amended 1930 empowers the Secretary of Agriculture to subject meats and meat products to inspection which are imported to the United States.

The Horse-Meat Act of 1919 extended the provisions of the Meat Inspection Act to include horse meat.

The Insecticide Act of 1910 has the purpose of preventing the manufacture, sale, or transportation of insecticides and fungicides, and for regulating traffic therein, and for other purposes similar to that of the Federal Food and Drug Act.

The Virus-Serum-Toxin Act of 1913 regulates the preparation, sale, and distribution of serums, etc., for use in treatment of animals.

Those administered by the Treasury Department:

The Harrison Narcotic Act of 1914, as amended and the Marihuana Tax Act of 1937 are basically revenue measures but also of public health significance since they regulate the traffic of dangerous narcotics. The Harrison Narcotic Act imposes annual taxes upon all importers, manufacturers, producers, compounders, wholesalers, retailers, physicians, and other practitioners who deal in or prescribe narcotics. It provides annual registration of all persons who dispense or deal with narcotics. The taxes imposed by federal narcotic acts are collected by the Bureau of Internal Revenue, but enforcement of the regulatory feature of these laws is entrusted to the Bureau of Narcotics, both in the Treasury Department. The Customs Bureau is concerned with the prevention of smuggling of narcotics into the United States. The U.S.P.H.S. cooperates with the Bureau of Narcotics in determining the quantities of crude opium and coca leaves that may be imported into the country for legitimate medical and other uses.

The Filled Cheese Act of 1896 as amended 1938, defines "filled cheese" and provides for the labelling of this cheese when shipped in interstate commerce. It also subjects such cheese to a tax at the rate of 1% per pound or fraction thereof. Filled cheese is defined as a substance made of milk or skimmed milk with the admixture of butter, animal oils or fats, vegetable or other oils, or compounds foreign to such milk made in imitation of cheese. This act is administered by the Commissioner of Internal Revenue.

Acts Relating to Oleomargarine, Renovated or Process Butter, Adulterated Butter:

Oleomargarine Act of 1886. The original act was chiefly a federal revenue measure, but also to save the consumer-public from deception as to the kind of product it was purchasing. In 1950, the tax on margarine was repealed.

This Act was amended in 1902 by the enactment of the Renovated or Process Butter Act. The latter act provides for the marking and branding of process or renovated butter before transportation and sanitary inspection at place of manufacturer. Both Acts are executed by Bureau of Internal Revenue. Since oleomargarine may contain animal fats, it is also subject to inspection under the Federal Meat Inspection Act administered by the Department of Agriculture.

Those administered by the Post Office Department:

The Postal Laws of the United States prohibit the use of the mails for fraudulent and misbranded materials which include foods and drugs; they also prohibit the transmission of poisons, explosives, disease germs, other dangerous articles, obscene matter, contraceptives and contraceptive information, and articles for procuring abortions.

Those administered by the Federal Trade Commission:

The Federal Trade Commission Act of 1914 as amended 1938 has for its purpose to supplement the Sherman Anti-Trust Act of 1890 by finding and eliminating "unfair methods of competition in commerce," but also to protect the public from "unfair or deceptive acts or practices in commerce."

Whereas the labelling of food and drugs is provided in the Federal Foods, Drug, and Cosmetic Act, the advertising of these items comes under the jurisdiction of the Federal Trades Commission.

The term "advertising" includes radio advertising. The term "false advertisement" is defined in this law as an advertisement, other than labelling, which is misleading in a material respect. In determining whether any advertisement is misleading, the law states that there shall be taken into account, among other things, not only representations made or suggested by statement, word, design, device, sound, or any combination thereof, but also the extent to which the advertisement fails to reveal facts material in the light of such representations or material with respect to consequences which may result from the use of the commodity to which the advertisement relates under the conditions prescribed in such advertisement, or under such conditions as are customary or usual. Advertisement of drugs is not to be deemed false if disseminated only to members of the medical profession if it contains no false representation of a material fact, and includes or be accompanied by a truthful disclosure of the formula showing quantitatively each ingredient of the drug.

Food Sampling

Below is outlined the number of samples and the size of each sample or subsample that should be collected of various types of food in order to represent an "Official Sample" for testing.

Beverages:

Soft Drink and Beverage Material

For filthy bottles: 500 bottles, or entire lot if less than 500.

For other than filth: 48 bottles.

Fruit Flavors: Expensive, highly concentrated flavors: Not less than 2 fluid ounces.

If product costs $2.50 or less per pint, collect 2 pints.

Dried products: 2 one-pound samples.

Fruit Juices and Beverages: 3 quarts, in original containers if possible from random cases.

Flavoring Extracts: Vanilla, lemon, etc.: not less than 1 pint.

Alcoholic Beverages: 3 pints, 2 quarts, or 1 gallon taken from different cases.

Bottled Beer:

For visible filth: 24 bottles from 500 candled bottles.

For filth or chemical additives: 48 bottles or cans.

1 keg for kegs up to 7 gals.

Cocoa: Breakfast:

Square root of number containers in lot, but not less than 6 nor more than 18.
Each subsample should be not less than 1 pd.

Coffee and Coffee Substitutes:

Retail packages: 1 package from each of 3 cases where there are less than 10 cases in lot.
1 package from each of 6 cases where there are more than 10 cases in lot.
Bulk: Sample 10 to 20 bags; each subsample about 1 pd.

Candy Plants:

For filth: square root of containers in lot, but not less than 6 nor more than 18 one or 2 pd. subsamples.

For mineral oil: Square root of containers in lot, but not less than 6 nor more than 15; subsamples not less than 1 pd. each.

For alcohol in candy: 3 unit packages.

For hazardous substances: At least one complete wholesale unit.

For maple sugar: 1 pd. from each batch. For large shipment, subsamples of 2 to 4 ounces each from not more than 10 different lots.

For maple syrup: Square root of containers, taking not less than 5 nor more than 12 subsamples. Repeat for each batch.

For honey, strained expressed: Square root of cases or bulk containers in lot, but not less than 5 nor more than 12 subsamples of not less than 1 pint each.

For comb honey: Square root of containers in lot, but not less than 5 nor more than 12 subsamples of not less than 1 pd. each.

Syrup and Molasses:

Size of Lot	Number of Samples	
	Quart size or smaller	Larger
Up to 50 cases	12	6
More than 50 cases	24	12

Butter:

	Number of Subsamples For:		
	Water Insoluble Acid & Butyric Acid	Filth	Fat & Moisture[1]
Print Butter			
Each Churn Mark of			
1 to 35 cases	1(2)	5	5
Over 35 cases	1(2)	8	8
No Churn Marks			
1 to 35 cases	12	12	12
Over 35 cases	12	20	20
Bulk Butter			
Each Churn Mark of			
1 to 2 units	1(2)	all	all
3 units	1(2)	2	2
Over 3 units	1(2)	3	3
No Churn Marks			
1 to 5 units	all	all	all
6 to 14 units	5	5	5
15 to 25 units	7	7	7
25 to 150 units	8	8	8
Over 150 units	8	14	14

1. All subsamples for fat and moisture are 8 ounces each.
2. Subsamples are 1.5 pds. each.
   All subsamples not otherwise designated are 1 pd. each.

Cheese

Cheddar:

Number of Cheeses	Number of Samples	
	Cores	Subdivisions
10 or less	3	1
11 - 30	6	2
31 - 50	9	3
51 - 75	12	4
76 -100	15	5

Swiss: Take sample from each cheese as follows:
3 cores from the flat surface of each wheel.
1 from center.
1 from half way between center and outer edge.
1 in the opposite sector near the outer edge.

Dry Milk: Sample the square root of the number of containers in the lot.

Bakery Products:

For filth analysis: Each subsample not less than 1 pd. Square root of number of shipping containers in lot but not less than 6 nor more than 18. If not in shipping containers, take square root of number of consumer packages (loaves, cakes, etc.), but not less than 6 nor more than 18.

For vitamin and mineral analysis: 6 loaves or units of partially baked or unbaked products.

Macaroni Products:

For egg solids in product: Enough packages to make 6 pds., but not less than 3 packages. From bulk boxes, 6 pd. composite sample from square root of number of packages in lot.

For filth: Retail size packages: Square root of number of shipping packages in lot, but not less than 6 nor more than 18 subsamples. Size of subsamples will vary with size of retail packages:

Package Size	No. Packages per Subsample
8 oz. and 10 oz.	3
12 oz. to 1 pd.	2
2 pds. and 3 pds.	1

Bulk Size cartons: For 20 pd. bulk cartons, take entire carton.

Collect not less than 2 nor more than 6 subsamples as follows:

From up to 30 cartons, take 2 subsamples
From 30 to 60 cartons, take 3 subsamples
From 60 to 90 cartons, take 4 subsamples
From 90 to 120 cartons, take 5 subsamples
From over 120 cartons, take 6 subsamples

For Vitamins and Mineral Determination: Collect 1 pd. subsample from 6 different shipping containers.

For slack fill: Collect 24 one pd. or smaller packages from 4 different cases.

Cereal Products

Alimentary pastes such as egg noodles, collect enough retail packages (not less than three) to make 5 pounds. From bulk packages, composite a 5 pound sample from the square root of the packages in the lot.

Flour: Take a sample from the square root of the number of bags in lot, but not less than 10.

Corn Meal and Buckwheat Flour: Same as for flour.

Grains and Feeds such as cottonseed meal, feed, calcium phosphate, and other phosphates:
Less than 25 sacks, sample all.

More than 25 sacks, sample square root of number of sacks, but not less than 25 sacks.

Eggs:

Shell eggs: 25 or less cases, sample 1/2 of 5 different cases; over 25 cases, sample 1/2 of cases equal to square root of the number of cases in lot.

Frozen eggs: If first 10 to 20 cans be good, take for granted the lot is good.

Sample the square root of the number of packages in lot, taking 1/2 pound from sample packages.

Nut and Nut Products:

Nuts in shell: At least 600 nuts

Shelled nuts: Sample the square root of the number of containers in the lot, but not more than 15 nor less than 5. Subsample from each container should be about 1 pound.

Jams and Jellies: Not less than 4 pounds.

If jars be smaller than 1 pound, sample 4 cases.

If jars be 1 pound or 2 pounds, collect one from each of 4 cases.

Vegetable Products

Sauerkraut

Barrelled Kraut: Take 2 quarts from each of 6 unopened barrels, but not less than 12 quart jars. For shipments of over 50 barrels, take 2 quarts from each of 12 unopened barrels.

Canned or Glass Pack Kraut:

Size of lot	Minimum Subsamples
Up to 50 cases	24 (2 pds. or less each)
Over 50 cases	48 (2 pds. or less each)

Tomato Products: Sample a representative number of codes.

For containers smaller than No. 10, take the square root of number of cases in lot, but not less than 12 when available. For containers of 10 ounces or less, collect at least 24 containers.

For containers larger than No. 10, take the square root of number of containers in lot, with minimum of 6 two pint subsamples. Add 15 c.c. of 37% formaldehyde to each pint jar.

For No. 10 and gallon containers, take square root of number of cases in lot, with maximum of 24 and minimum of 6 subsamples.

Pickle Products:

If in barrels, collect 12 half-gallon jars with brine, 2 from each of 6 previously unopened barrels.

If in tank cars, collect minimum of 12 half gallons with brine.

For quart or smaller jars, collect 24 jars from lots up to 100 cases, or 48 jars from lots of over 100 cases.

For gallon jars, collect 12 jars from lots up to 100 cases, or 24 jars from lots of more than 100 cases.

Fresh vegetable: Cabbage, cauliflower, peppers, squash, cucumbers, egg plants, etc.

Collect 10 specimens from the lot for larger vegetables.

Collect 4 pounds of small vegetables from lot.

Celery: 14 stalks from lot, at least one from each crate.

Dried beans: At least 4 quarts; sample at least 10% of bags in a lot over 100 bags. Lots less than 100 bags, sample 10 bags.

Olives:

		Quart Size Containers or Smaller	One Half to One Gallon
Packaged:	Up to 50 cases	12	6
	More than 50 cases	24	12

Bulk: Sample the square root of the number of containers in lot but not more than 24. Each subsample is 1 quart.

Vinegar:
Bottles, take enough to total 2 gallons. Barrels, sample 3, taking 1 gallon from each.

Meat and Meat Products

Poultry and Rabbit: Sample every barrel where there are 3 or less barrels. Sample square root of barrels where there are more than 3 barrels, but not less than 3 barrels should be sampled.

Ground Fresh Meats, such as hamburger, pork sausage (either bulk or links), sausage meats, etc.: Take at least 1 pound.

Smoked Sausage: Take one ring or length.

Prepared Sausage, such as weiners, frankfurters, bologna, and other similar types: Take one ring if put in rings; take at least 2 pounds, if put in lengths, cans, or other units of two pounds or more.

Fish, Clams, Oysters, Salmon, Sardines, Mackerel, Tuna, Shrimp, Herring Roe:
Canned: Take one can from each case, unless there be fewer than 48.

Number of Cases	Number of Cans for Sample
Below 200	48
200 - 1,000	96
1,000 - 2,000	192
2,000 - 5,000	288
5,000 - 10,000	576
10,000 - or more	960

Frozen: If units consist of 10 or 15 pound boxes:

Less than 100 boxes - sample 6 units
100 to 300 boxes - sample 10 units
300 to 500 boxes - sample 15 units
500 to 1000 boxes - sample 20 units
Over 1000 boxes - sample 30 units

Shrimp, cooked, peeled, headless: Collect four subsamples of 8 ounces each from different containers in each barrel. Each subsample includes pieces from top, bottom and middle of the can.

Fresh Oysters: See Chapter on Seafood Control. For pint containers, sample in multiples of 8, i.e., one out of every 8 containers.

Canned Crab Meat: If there be more than 1 barrel and less than 10, submit 2 subsamples from each barrel. If there be more than 10 barrels, submit 1 subsample from each barrel. Each subsample is at least 2 ounces.

Olive Oil and other foods:
Sample all sizes: 3 original packages if they be smaller than 1/2 gal.
2 original packages if they be 1/2 gallon.
1 original package if they be 1 gallon.
For bulk: If there be 3 or less containers, take 4 fluid ounces from each.
If there be 4 to 16 containers, take 4 fluid ounces from four.
If there be 16 or more containers, sample the square root of the number of containers.

Spices and Condiments

Mayonnaise, Mustard, and Salad Dressing: At least 2 quarts. Collect 12 jars if there be 10 cases or more in lot; sample proportionally if there be less than 10 cases.

Canned Food (those not before mentioned)

Size Cans	Minimum number of subsamples
No. 3 and smaller cans	
Small lots	24 cans
Up to 1,000 cases	48 cans, 1 from a case
1,001 to 3,600 cases	72 cans, 1 from a case
Larger than No. 3	
Up to 600 cases	24 cans, 1 from a case
601 to 900 cases	30 cans, 1 from a case
901 to 1,300 cases	36 cans, 1 from a case

Table 22. Square Roots

4 - 2	324 - 18	1,156 - 34	2,500 - 50	4,356 - 66
16 - 4	400 - 20	1,296 - 36	2,704 - 52	4,624 - 68
36 - 6	484 - 22	1,444 - 38	2,916 - 54	4,900 - 70
64 - 8	576 - 24	1,600 - 40	3,136 - 56	5,184 - 72
100 - 10	676 - 26	1,764 - 42	3,364 - 58	5,476 - 74
144 - 12	784 - 28	1,936 - 44	3,600 - 60	5,776 - 76
196 - 14	900 - 30	2,116 - 46	3,844 - 62	6,084 - 78
256 - 16	1,024 - 32	2,304 - 48	4,906 - 64	6,400 - 80

Technique for Collection and Shipment of Samples.

Material: Sterile fruit jars; sterile forceps; shipping containers.

Conditions for which examination is made:

a) Infection by pathogenic organisms.
b) Contamination by toxic materials.
c) Putrefaction.
d) Adulteration and misbranding.

Procedure for Collection, Storage and Shipment.

1. Canned, Bottles or Otherwise Packaged Food. The collection of materials requires that an adequate amount and adequate selection of samples be made, and that the packing of the materials be such that the containers be not injured in shipment. Such samples as require refrigeration must be packed in ice and maintained at desired temperature during shipment.

2. Live Foods. Samples such as unshucked oysters, clams and mussles must be packed in clean containers and handled and shipped under such temperature conditions and cleanliness as will keep the sample material alive and prevent their infection.

3. Non-living Foods.

a. Perishable Foods. Such samples must be collected, packed and shipped under temperature conditions and cleanliness as will prevent spoilage. A temperature of 50° F. or below should not be allowed to freeze except for foods which are kept or processed at approved freezing temperatures. These samples should be packed in sterile containers, and provided with outside containers into which ice is packed. No ice or other foreign substance should be allowed to come into direct contact with the samples. In packing sample, care should be taken that material not be damaged or injured in shipment.

b. Non-perishable Foods. Such samples must be collected in sterile fruit jars, or, as the case may be, in suitable clean containers. If sterility be maintained, sterile implements should be used to transfer food to jar or container.

The size of sample depends upon the quantity of material inspected as already described in the foregoing paragraphs. When a set of tables is not available for indicating the size of samples to be taken, the following rule may be used:

Sample that number of cases which is equal to the square root of the number of cases in the lot, being sure that the samples come from well scattered cases. Example: a lot of 144 cases would require samples from 12 cases. At least 2 cans or bottles are usually taken from each case sampled.

The information slip should be filled out as completely as possible. The sanitarian should indicate on slip what he thinks is wrong with sample. If the product has a code number, mark it on the information slip. Make note as to the amount of the sampled material left in stock.

All lids or caps of containers which are not considered as integral parts of the containers, should be sealed with the State Seal in such a way that opening the lid or caps would necessitate the breaking of the seal. The seal should be signed by the sanitarian.

Chapter XX

Meat and Meat Products Control

The role of the sanitarian in food and drug control has already been noted. His role in meat control is similar but specialized. Why should meat control be distinguished from food control in general? There are several types of foods which, due to their special way of production and special relation to health problems, present special considerations from health authorities. These are milk and milk products, frozen desserts, meat and meat products, seafood, and poultry and eggs.

The sanitation of abbottoirs, slaughtering houses, stock yards, establishments and premises where any meat product is prepared, handled, or stored, and vehicles of transportation is in the sphere of the sanitarians work. The ante-mortem and post-mortem inspections of food animals are primarily the work of the veterinarian, but specially trained sanitarians may serve as assistants to and work under the supervision of veterinarians in this phase of meat control. The sanitarian must know the hygienic techniques used in the processing of meat products to prevent adulteration with dyes, preservatives, fillers or any deleterious substance, and to prevent the use of misleading labels. In less populated and rural areas where veterinarians are not easily available, the sanitarian may actually be responsible for detecting sick animals before slaughter and for stamping meat after slaughter. Even in such cases arrangements should be made, if possible, to have veterinarian consultation as often as feasible. The sanitarian should therefore have some understanding of the simpler and more obvious signs and symptoms of disease, observed on inspection, that may be reason to prevent the slaughter of animals for human consumption.

Such inspections include a search for evidence of such conditions as immaturity, advanced pregnancy, recent parturition, fatigue, exhaustion, or injuries. If tired animals be killed before being rested, bleeding may be incomplete and the quality of the meat impaired. The flesh may contain toxic bodies which are harmful to man. The meat of immature, pregnant or recently parturient animals is of inferior grade. The body temperature of suspected animals should be taken and recorded. A sick animal may be recognized by: Rough or "staring" coat, dry nostrils or covered with foam, heavy or droopy eyes, protruding tongue, labored breathing, slow and difficult movements, diarrhea or blood stained urine, tendency of the animal to isolate itself from the herd, elevated body temperature.

The slaughter of fatigued or exhausted animals should be delayed 6 to 12 hours or more. All sick animals should be segregated. Certain precautions should be taken before slaughtering. Animals should not be fed for about 24 hours before slaughtering in order to insure clean intestines and good flavoured meat. They should not be excited since this produces poor bleeding which mars the appearance of meat and disposes it to quicker decay.

Condemnation of Animals

Any animal which, on ante-mortem inspection, does not plainly show, but is suspected of being affected with, any disease or condition that may cause condemnation of the carcass on post-mortem inspection, and any animal which shows, on ante-mortem inspection, any disease or condition that would cause condemnation of only part of the carcass on post-mortem inspection, should be so marked as to retain its identity as a suspect until final post-mortem inspection, when the carcass should be marked and disposed of in accordance with regulations.

Conditions which require condemnation of animals when found on ante-mortem inspection are:

1) All conditions which would be condemned if found on post-mortem inspection.

2) Temperature of 106° F. or higher in swine. Temperature of 105° F. or higher in cattle, sheep, or goats. At the discretion of the inspector such animals may be branded as suspects.

3) Coma or semi-coma except at the discretion of the inspector.

4) Serious crippling except at the discretion of the inspector.

5) Rabies, tetanus, tuberculosis with fever or cachexia (tuberculin reactors should be handled as suspects), epithelioma of the eye and orbital region with extensive infection and necrosis or cachexia, anthrax, anasarca or generalized edema.

6) Although animals found with the following conditions may be condemned, they may, at the discretion of the inspector be set apart and held for treatment under responsible official supervision: Hog cholera, swine erysipelas, vesicular exanthema, vesicular stomatitis, railroad sickness, parturient paresis (milk fever), anasarca, inflammatory conditions including pneumonia, enteritis, peritonitis.

The disposition of animals rejected outright at ante-mortem inspections depends on the circumstances and the nature of the cause for rejection. Dying animals and those that have diseases communicable to other animals or to man should be destroyed by being tanked, incinerated or treated with some denaturing substance such as a phenol compound, oil, or quick lime, and buried. The carcasses of animals found to have anthrax should be completely incinerated or tanked. If desirable from an economical point of view, animals rejected outright for food purposes because of injuries, or diseases which will yield to treatment, or other curable conditions, may be released for purposes other than food. The instruments and the killing beds used to slaughter animals with diseases or suspected of diseases communicable to man or other animals should be sterilized with 1:1000 solution of bichloride of mercury.

All conditions for which animals should be rejected cannot be detected by ante-mortem inspection and must be found in post-mortem inspection. Animals suspected of diseases or abnormal conditions which do not justify ante-mortem rejection, either outright or tentative, may be passed for slaughter as suspects and final action taken in accordance with post-mortem findings. The carcasses of such animals should be inspected separately from normal carcasses.

A post-mortem inspection is an examination of the carcass or parts of a carcass, of a freshly slaughtered food animal for evidence of a disease or abnormal condition which would render it unsuitable for food. Such inspections should be made at the time of slaughter or immediately thereafter using a predetermined routine such as, the examination of head, viscera, and then the various parts of the body. The instruments necessary for a post-mortem examination are contained in a meat and dairy inspection case which holds the following: 4 and 6 inch post-mortem knives, note book, inking pad, sharpening stone, 5 and 8 inch meat triers, 10 inch steel, 18 inch lard and butter trier, meat inspection rubber stamp, marking ink container, 6 inch cheese trier, clinical thermometer, dairy thermometer, 8 inch gland hook or tenaculum, can opener, flashlight, and pocket magnifying glass.

Conditions which require condemnation of the whole carcass when found on post-mortem inspection:

1) Conditions listed for condemnation on ante-mortem inspection.

2) Generalized or suspected generalized tuberculosis, or tuberculosis with cachexia, generalized diamond-skin disease, arthritis and polyarthritis with suppurative lesions in more than one joint, generalized actinomycosis, generalized actinobacillosis, anaplasmosis, anthrax, bacillary hemoglobinuria in cattle, blackleg, hemorrhagic septicemia, icterohematuria in sheep, malignant epizootic catarrh, piroplasmosis, diffuse necrobacillosis, caseous lymphadenitis with thin carcass, unhealed vaccine lesions (vaccinia), malignant neoplasms with marked extention to other parts, generalized melanosis, icterus with degenerative changes in organs, mange or scab with extensive emaciation and inflammation, generalized brucellosis.

3) Conditions where carcasses may give rise to food poisoning: Acute inflammation of lungs, pleura, pericardium, peritoneum or meninges, gangrenous or severe hemorrhagic enteritis or gastritis, septicemia or pyemia, whether puerperal, traumatic or without any evident cause, acute diffuse metritis or mammitis, phlebitis of the umbilical veins, septic or purulent traumatic pericarditis, any acute inflammation, abscess, or suppurating sore if associated with acute nephritis, fatty or degenerated liver, swollen soft spleen, marked pulmonary hyperemia, general cachexia, icteric discoloration of carcass, or the like, either singly or in combination.

4) Cysticercus bovis (tapeworm cysts), when incisions into various parts of the musculature expose on most of the cut surfaces two or more cysts within an area the size of the palm of the hand; cysticercus cellulosae, when infestation is excessive; cysticercus ovis (sheep tapeworm cysts), when infestation is generalized.

5) Emaciation or anemia plus evidence of tissue degeneration, unborn and stillborn animals, suffocation, scalding of live hogs.

6) Other diseases which should require condemnation of the whole animal: Rinderpest (cattle plague), foot and mouth disease, glanders (may be found in sheep, goats and horses), bradshot (rapid plague in sheep), white sour (in calves).

Animal organs are condemned when the whole carcass is condemned, and when the organ is found infected, infested, degenerated, or showing any abnormal condition.

7) Horses should be condemned when the following conditions are found on ante-mortem or post-mortem examination: Strangles, purpura hemorrhagica, azoturia, infectious equine encephalomyetitis, toxic encephalomyelitis (forage poisoning), infectious anemia (swamp fever), dourine, acute influenza, generalized osteoporosis, glanders, farcy or other malignant disorder, acute inflammatory lameness or extensive fistula.

Trade Terms for Animals are:

Cattle: Bull is an entire male; ox is a castrated male; steer is a castrated male up to 1 1/2 to 2 years of age; stirk is a male or female, entire or not, about 1 year of age; bull calf is an entire male calf; heifer calf is a female calf; heifer is a young cow before calving; cow is a female after calving.

Sheep: Ram is an entire male; tup is an entire young male; wether (or widder) is a castrated male; ewe lamb is a young female; teg is a young sheep, either sex, entire or not.

Pigs: Boar is an entire male; hog is a castrated male; porker is a young pig, either sex, entire or not; sow is a female after having had a litter; gelt is a female not having had a litter; shoat or shote is a young hog.

Goats: Billy is an entire male; wether is a castrated male; nanny is a female; kid is a young goat, either sex.

Stag is a bull, ram or goat, castrated at maturity.

Store cattle, sheep or pigs are animals kept for breeding, or if for market, not yet fatted.

Fresh Meat and Meat Products.

The inspection of fresh meat and meat products is ordinarily concerned with the nutritive and sanitary quality of the product and with its wholesomeness and conformity with purchase specifications.

The prevention of infections and poisoning from meat and food products depends upon the health of the animal, the mode of its death, and the method of butchering, preserving, and handling of the flesh.

System of Grading: The carcass meat of different food animals is separated by trade and inspection practices into grades which are determined by various factors pertaining to the quality and appearance of the product. Fundamentally, the grading of carcass meat is based on quality, finish, and conformation, together, in some instances, with age, sex, weight, and many other minor factors which determine the quality and finish. The soundness of meat governs its sanitary and nutritive qualities. But from the viewpoint of health protection the sanitary quality is the most important factor to be determined by inspection. The other attributes of fresh meat, such as finish and conformation, determine the grades required for commercial reasons, and, in some instances, indicate in general the nutritive value and desirability of the product as an article of food. They are very important insofar as purchase specifications are concerned, but do not effect the soundness of the meat.

Soundness of Fresh Meat. Meat is considered unsound which has deteriorated or undergone any undesirable changes subsequent to post-mortem inspection, has evidence of bruising, was inadequately bled, shows mutilation, shows fibrillar muscular ruptures, shows evidence of

processing with preservatives, has not passed ante-mortem and post-mortem inspections, and has not been officially stamped.

Bacterial Decomposition of Fresh Meat. Meat of healthy animals is generally free of bacteria. Bacterial decomposition occurs after slaughter. Due to handling, a certain amount of contamination by bacteria and fungi is not preventable and if not protected by proper storage and refrigeration may spoil the meat. Under unsanitary conditions the meats may be contaminated by pathogens.

Bacteria and fungi are found always on the surface of freshly slaughtered meat. These organisms come from the air, hands and clothing of workers, utensils and equipment. Organisms may be carried into the tissues of the meat by contaminated instruments during dressing of the carcass. Penetration may be facilitated by delay in removal of viscera, inadequate chilling, by fatigue at time of slaughtering, and in case of hogs, by prolonged exposure in the scalding vat. Excessive surface contamination may also promote rapid penetration of organisms into the interior of meat. Dryness and hardness of the meat surface decrease the rate of penetration. Thus thoroughly dried meat which has been chilled decreases the ability of bacteria to grow and to penetrate. Conversely, a moist and relatively soft surface is conducive to rapid bacterial growth and penetration. Under such conditions, particularly if the air be moist, a layer of slime consisting of bacteria and fungi is formed and spoilage is hastened.

Under average conditions of dryness and hardness, bacteria will penetrate meat at the rate of about 1/2 inch in 30 days. The depth of penetration is manifested by a dark well defined discoloration of the meat.

Bacteria may penetrate rapidly along moist surfaces between muscular tissue and through open blood vessels.

Refrigeration of Fresh Meat. All fresh meat must be chilled to remove the animal heat. If not sold in this state it must be frozen and stored. Improper chilling promotes bacterial decomposition. Rooms used for chilling are called chill rooms or coolers; rooms used for freezing are called freezers. All refrigeration systems must have adequate ventilation in order to carry away steam, moisture and odors. If warm and chilled carcasses be placed in the same chill room, moisture will condense on the chilled meat and produce slime. Therefore the initial chilling is done in the "fore cooler", before being placed in the main cooler. Freshly dressed carcasses are hung in fore coolers so that a space for air circulation is present. Here they remain for a period of 18 to 24 hours at a temperature from 34 degrees F. to 38 degrees F., and then transferred to the main cooler for about 2 days at a temperature of from 32 degrees F. to 34 degrees F.

Meat stored in a refrigerator or ice box should not be wrapped in paper. Nor should it touch the side of the box or the ice. It should be so placed as not to cause accumulations of dripping. Ice boxes or refrigerators can be effectively cleaned with soda.

Firm, well finished beef may be stored in chill rooms under proper condition for 30 days, without marked deterioration. Carcasses that do not become firm on chilling tend to deteriorate rapidly and should not be kept in chill room longer than the chilling period. Chilled fresh pork tends to deteriorate more quickly than other meats under the same conditions. Frozen meats can be held in storage until required for consumption. Properly chilled meats are frozen in temperatures from 10 degrees F. below to 10 degrees F. above zero. After freezing, the meat is stored at temperatures ranging from zero F. to 10 degrees F. It can remain in this state over a long period of time.

If meats be not defrosted properly they tend to undergo rapid bacterial decomposition. They should be first stored for about 4 days in a well ventilated cooler at 38 degrees F. In an emergency, rapid defrosting at 70 degrees F. is possible, but the slow method should be used when practicable. Meats thawed in water spoil rapidly.

Meats removed from refrigerators and stored immediately in chill rooms at about 35 degrees F. will usually remain free from decomposition for 6 to 10 days. If stored in ice boxes at 45

degrees to 55 degrees F., evidence of decomposition may appear in 72 hours. Meats purchased from local establishments, should not be held in the refrigerator or ice box of the home for more than 24 hours prior to cooking. Meat stored in an ice box should not be in contact with the ice or walls, but should be hung from hooks with plenty of space around it for air circulation.

Inspection of Fresh Meat. Inspection of fresh meat is made principally by direct observation. If meat be wrapped, unwrap it. Good high grade meat is dry, firm to the touch, normal color and free from abnormal odors. Wet, slimy or mouldy surfaces are indicative of beginning surface spoilage.

The color of choice fresh meat should be:

Beef	bright red
Veal	pinkish brown
Mutton	dark pink or red
Lamb	light pink
Pork	light pink

Abnormally dark colors are caused by aging, overheating, disease at time of slaughter, improper bleeding, prolonged storage in chill room, or exposure to warm air after removal from chilling room or after defrosting. Abnormally pale colors are evidence of immaturity. Sour, putrid or other abnormal odors indicate spoilage.

Decomposition of deep tissues most frequently occurs around large joints or long bones. Any evidence of improper chilling may be indicative of decomposition of deep tissues. Where suspected, a trier should be passed down to the bone or an incision made. If decomposition be present the characteristic odor will be given off from the trier, or from meat if an incision be made. Fresh meat should be inspected also for bruising, fibrillar muscular rupture, stamp markings, sanitary conditions.

To test whether deep tissues are decomposed when surface tissues show signs of thawing, pass a wooden auger which will penetrate only thru the soft tissues and stop at the well frozen portion.

If decomposition had occurred in the deeper tissues before the meat was frozen, it will not be detected by ordinary inspection. When suspected, take a sample of deep tissues around long bones or large joints with an auger. Then the ammonia test (Eber test) is performed on the defrosted sample warmed to room temperature. See chapter on field tests.

Decomposed meat when thawed out will also give the characteristic odor of spoiled meat. Sometimes if the meat be boiled the characteristic odor is developed. Partial rejection of meat may be satisfactory where the decomposition is limited to a very small area consisting of slime on the surface, otherwise complete rejection is the rule.

All products whether fresh, cured, or otherwise prepared, even though previously inspected and passed, should be reinspected as often as may be necessary in order to ascertain whether they are sound, healthful, wholesome, and fit for human food at the time they are placed in commerce.

Inspection of Cured, Canned, and Other Meat Products. The processes of curing and canning meat involve a variety of techniques, procedures and specifications related to the meat, the ingredients, the containers and wrappings, the utensils, the housing, and the personnel. Regulations to cover the inspection of these products therefore are quite technical in many aspects and cannot be separated from the regulations for the inspection of fresh meat since these products are processed from fresh meat. The first phase of inspection of cured and canned meat products therefore is really the inspection of fresh meat products. All fresh meat products which are used for canning and curing must pass all the requirements of ante-mortem and post-mortem inspection. Since much of the canned and cured meat products may be consumed without further cooking, the processes involved in preparing such products must be rigidly carried out in order to reduce to zero any hazard present in the fresh meat or any potential hazard in handling.

Cured Meats. Cured meat is meat preserved with chemicals or by drying, and includes salted,

smoked, pickled and dried meats. Cured meat should be stored in dry, well ventilated store rooms at a temperature between 40 degrees F. and 50 degrees F. Good air circulation and freedom from dampness are essential. Each piece should hang free from contact with another piece. If crated, the crates should be stored so as to permit the circulation of air around each crate. The keeping qualities of smoked meat depend considerably on the methods of curing and storing. Under good conditions smoked meat may be stored without damage for 30 to 60 days. Sugar cured ham and breakfast bacon should not be kept in storage for more than 30 days. Properly stored salted meats will keep for relatively long periods.

Usually, if a considerable quantity of meat be inspected, about 10% of the pieces are examined. If any unsound meat be found, the whole lot should be inspected. The examination consists in looking for bruises, mutilation, discoloration, soft white spots, slime, mold, insect larvae, infestation, rodent droppings, sourness, rancidity, or other indications of decomposition, or evidence that the meat has been trimmed to remove unsound portions. In smoked meat, decomposition usually occurs first in bone marrow, or tissues adjacent to bones and joints. Occasionally decomposition occurs in deep tissues of hams. In bacon, small areas may undergo decomposition. The deep tissues of smoked meat should be examined by inserting a trier into the body of the piece in the vicinity of the rib attachments and string holes, and around the bones and joints. Upon withdrawal, the trier is examined for any abnormal odor indicative of spoilage. The surface should be examined for soft, white or uncolored areas caused by contact between the pieces during the smoking process or faulty handling prior to smoking. The wrappings should be inspected for tears or holes. The storage conditions should be determined with particular emphasis to circulation, moisture, and temperature.

All cured meat should show official stamping or be rejected. Unstamped meat should be given a most meticulous examination, and passed as food only after finding it unquestionably free from defects. All decomposed cured meat should be rejected unless the area involved be very small and superficial and easily removed. Meat infested with larvae should be rejected, except where slightly infested meats can be easily and successfully trimmed. Meats with surface mold and slime if not extensive may be salvaged by wiping the surface with a cloth or by washing with dilute solution of vinegar in water. Mutilated or torn meat showing white areas due to improper smoking should be rejected.

Canned Meats. Canned meats are meat products which are preserved in hermetically sealed metal or glass containers. Deterioration of canned products is caused by faulty canning methods and by any defect in the can which will admit air and contamination. Spoilage or damage is indicated by evidence of defective cans or of decomposition of the contents of the can. The inspection is made by examination of the unopened can and of the contents of suspected or selected cans. An acceptable can should be firm, tight, free from loose tin, dents or rust. If the contents of a can be sound, the ends of round cans and sides of square or flat cans are concave, due to the vacuum created during the canning process. Insufficient vacuum or loss of vacuum with consequent flattening or bulging of the ends or sides is due to defects which permit air to enter the can or to decomposition of the contents with gas formation. Defective canned goods is classified according to the nature of the defect as previously described.

Any canned meat or product which requires sterilization to preserve it should be sterilized on the same day that the cans are filled. Defective or leaky cans discovered after the process of sterilization has been completed should not be repaired or repacked (a) unless the repairing, or repacking be completed within six hours after the process of sterilization has been completed, or (b) if their defective or leaky condition be discovered during an afternoon run, and they be held in coolers of a temperature not exceeding 38 degrees F. until the following day, when they may be repaired or repacked. Sterilization is deemed completed when the cans have sufficiently cooled for inspection and handling. The contents of all defective or leaky cans not repaired or repacked are to be condemned.

Unless labeled at once, canned meat and products should be marked so as to maintain their identity until the final label is attached.

Sausage: This is a mixture of ground meat and usually contains condiments. It is made of fresh cuts, trimmings, or offal parts. Any of the pure spices may be used and salt and saltpetre

may be employed in the curing process. If sodium benzoate be used as a preservative, its presence and amount must be stated on the label. Cereal may be used in proportion of not more than 2%. Water or ice may be added as needed during the process of manufacture in quantities not to exceed 3%, except that frankfurt, vienna, or bologna style sausage may contain enough water in excess of 3% to render the product palatable.

Meat sausage is classified as fresh, smoked, cooked, and dry. Fresh sausages usually consist of fresh pork, or pork and beef. The smoked and cooked products include among others, the frankfurt, bologna, vienna, liver, wiener and luncheon sausages. The dry or summer sausages include the Italian, German, French and other styles of dried sausages, which may or may not be smoked.

Fresh sausage is prepared in bulk form, or packed in cartons or cans or stuffed into casings. Smoked, cooked, or dry sausages are stuffed into casings or packed in cans or other containers. The natural or animal casings consist of the stomach, large or small intestines and urinary bladders of sheep, and the esophagus, large and small intestines, and urinary bladders of cattle. Artificial casings are made of parchment paper, paraffined muslin bags, or cellulose material of various kinds.

Owing to the nature of the products, special precautions should be taken to prevent contamination during the manufacture of sausage. All animals from which the meat or casings are derived should be subject to official ante-mortem and post-mortem inspections.

Fresh sausage may be kept for not longer than one week, and smoked or cooked sausage for not more than 2 weeks, in well operated and dry coolers. Dry sausages, if they be kept dry, may be held without spoilage for long periods of time at a temperature of 36 degrees F. Sausage is inspected in the same manner as other meat products. Any product prepared under unsanitary conditions or showing evidence of slime, mould, discoloration, sourness, friableness, undue softness, abnormal odor, should be rejected. Samples are shipped in same manner as any fat product.

Fats. Rendered animal fats of an edible nature are principally derived from beef, pork, and mutton. Beef fats are rendered into oleo stock and edible tallow. Oleo oil and oleo stearin are obtained from oleo stock. Oleo oil is used in the production of animal margarine. Oleo stearin is used in the manufacture of candy, margarine, and lard substitutes. Edible tallow is employed in the manufacture of lard substitutes, lard compounds, margarine and for baking purposes. Pork fats are rendered into lard, or enter into the production of lard compounds, lard stearin, lard oil, and margarine.

The pork fats from which lard is obtained are classified, generally, as leaf, cutting, killing or butcher, and cured fats. Leaf fats constitute the best grade and are obtained from the retroperitoneal layer of fat. Cutting fats are obtained from the ham, shoulder back, and other cuts, and are inferior to leaf fats, but will, if properly handled yield a good grade of lard. Killing fat is fat which is removed from the carcass during the dressing process and from the offal. It produces a dark colored lard which may have an abnormal odor. Cured fats are obtained from cured pork. Lard made from cured fats is dark in color and usually has a flavor corresponding to the kind of cure used.

Kettle rendered lard is rendered in open or closed kettles which are heated by steam or fire. The fat does not come in contact with steam and is not under pressure while being rendered. It is made from leaf fat alone or leaf fat and cutting fat.

Steam rendered lard is rendered in tanks by the direct application of steam under pressure. All edible hog fat may be used in its production, but the better grades as represented by prime steam lard are made from approximately 60% cutting fat and 40% killing fat. Prime steam lard is not bleached, filtered or otherwise refined. It has a coarse grain and characteristic flavor due to the method of cooking.

Refined lard is produced from prime steam lard by agitation, filtering, bleaching, and chilling. It is smoother and more homogeneous than prime steam lard and has a better flavor.

Lard compounds are made by combining lard with other fats such as vegetable oil, lard stearin, oleo stearin, or tallow. An acceptable product should contain at least 50% lard.

Lard substitutes are compounded from various mixtures of vegetable oils, or animal fats and vegetable oils. Deodorized coconut, cottonseed, corn, soya or peanut oils may be used, either along or in combination with lard, oleo stearin or tallow. The animal fats are used to stiffen the product and raise the melting point. Lard substitutes should be so made that they will remain solid at a temperature of 70 degrees F.

Lard is packed for shipment or storage in tierces, cartons, pails, boxes, barrels, tubs, kegs, or drums. Lard destined for use in the tropics, or for export generally, may be made more firm by the incorporation of hydrogenated* lard or lard stearin. Lard should be stored in a dry place at a temperature of not more than 36 degrees F. Lard substitutes do not keep as well as refined lard and should not be stored for longer than 30 to 60 days. Refined lard, when stored at a temperature of not more than 36 degrees F. should remain in good condition for at least a year. Unsound fats and contamination of the rendered product reduce the keeping qualities of the finished product. Lards containing moisture tend to become rancid, or sour. Relatively high storage temperatures promote the production of rancidity, and sourness, especially if the lard be old or becomes soft.

The whole process of lard production should come under the same scrutiny as any meat or meat product. Lard should be white, smooth and firm, and free from discoloration, abnormal odors or flavors. Samples should be obtained by inserting a trier to the bottom of the container, since there is where decomposition first occurs due to moisture accumulation. Abnormal odors may be easily detected if a sample be heated, or warmed by rubbing between the fingers or palms. A trier sample should be placed in a glass, tin, or other non-absorbent container having a tight lid so that no moisture will be lost, and then it should be shipped to the laboratory. The sample must not be wrapped in paper. At the laboratory, examinations are made for adulteration, presence of fatty acids, and to determine the iodine number, together with such other analyses as may be indicated. Lard should contain not more than 1% free fatty acids. The moisture content of kettle rendered lard should not be more than 0.1%, and that of steam rendered lard not more than 0.3%. The melting point should be between 86 degrees F. and 113 degrees F.

Any fat product found to be rancid, sour, mouldy or adulaterated should be rejected. If only a small portion be rancid the remainder may be passed. If only the surface be mouldy, the remainder may be passed.

Oleomargarine: Identity and Standard. Oleomargarine is the plastic food prepared with one or more of the optional fat ingredients named in the following 4 subparagraphs:

1) The rendered fat, or oil, or stearin derived therefrom (any or all of which may be hydrogenated), of cattle, sheep, swine, or goats, or any combination of two or more of such articles. (Labelled: "Prepared" or "Made from Animal Fat.")

2) Any vegetable food fat or oil, or oil or stearin derived therefrom (any or all of which may be hydrogenated), or any combination of two or more of such articles.

3) Any combination of ingredients named under 1. and 2. in such proportion that the weight of the ingredients named under 1. either equals the weight of the ingredients named under 2, or exceeds such weight by a ratio not greater than 9 to 1. (Labelled: "Prepared" or "Made from Animal and Vegetable Fat.")

4) Any combination of ingredients named under 1. and 2. in such proportion that the weight of the ingredients named under 2. exceeds the weight of the ingredients named under 1. by a ratio not greater than 9 to 1. (Labelled: "Prepared" or "Made from Vegetable or Animal Fats").

One of the following five articles is intimately mixed with the fat ingredient or ingredients, after such article has been pasteurized and subjected to the action of harmless bacterial starters: a) cream, b) milk, c) skim milk, d) any combination of dried skim milk and water in which the weight of the dried skim milk is not less than 10 percent of the water, or e) any mixture of two or more of these. (The term "milk" as used herein means cow's milk.) Congealing is effected,

*Hydrogenation is the addition of hydrogen to vegetable oils in order to render them more solid at ordinary temperatures.

either with or without contact with water, and the congealed mixture may be worked. In the preparation of oleomargarine one or more of the following optional ingredients may also be used:

1) Artificial coloring. (Labelled: "Artifically Colored," or "Artificial Coloring Added," or "With Added Artificial Coloring.")

2) Sodium benzoate, or benzoic acid, or a combination of these, in a quantity not to exceed 0.1 percent of the weight of the finished product. (Labelled: "Sodium Benzoate", or "Benzoic Acid," or "Sodium Benzoate and Benzoic Acid Added as a Preservative," or "With Added . . . . as a Preservative.")

3) Vitamin A, added as fish liver oil or as a concentrate of Vitamin A from fish liver oil (with any accompanying Vitamin D and with or without added Vitamin D concentrate,) in such quantity that the finished oleomargarine contains not less than 9,000 United State Pharmacopoeia Units of Vitamin A per pound. (Labelled: "Vitamin A Added," or "With Added Vitamin A.")

4) The artificial flavoring diacetyl added as such, or as starter distillate, or produced during the preparation of the product as a result of the addition of citric acid or harmless citrates. (Labelled: "Artificially Flavored" or "Artificial Flavoring," or "With Added Artificial Flavoring.")

5) (a) Lecithin, in an amount not exceeding 0.5 percent of the weight of the finished oleomargarine, or (b) monoglycerides or diglycerides of fat-forming fatty acids, or a combination of these, in an amount not exceeding 0.5 percent of the weight of the finished oleomargarine, or (c) such a monoglycerides and diglycerides in combination with the sodium sulfo-acetate derivatives thereof in a total amount not exceeding 0.5 percent of the weight of the finished oleomargarine, or (d) a combination of (a) and (b) in which the amount of neither exceeds that above stated, or (e) a combination of (a) and (c) in a total amount not exceeding 0.5 percent of the weight of the finished oleomargarine. (The weight of diglycerides in each of ingredients (b), (c), (d) and (e) is calculated at one-half actual weight.)

6) Butter.

7) Salt.

The finished oleomargarine contains not less than 80 percent fat, as determined by the method prescribed in "Official and Tentative Methods of Analysis of the Association of Official Agricultural Chemists," 4th Edition 1935, page 289, or 5th Edition, 1940, page 298, under "Indirect Method - Official."

Where oil is used, the word "oil" may be substituted for "fat" in the label statement. In lieu of the word "animal" or "vegetable" in any such statement, the common or usual name of the fat ingredient may be used. If two or more of the optional ingredients named above, in 5, 6, 7, and 8 be used, the words, "added" or "with added" need appear only once, either at the beginning or end of the list of such ingredients declared. The declaration of Vitamin A may include the number of United States Pharmacopoeia Units which have been added.

Whenever the name "oleomargarine" appears on the label so conspicuously as to be easily seen under customary conditions of purchase, the words and statements herein prescribed showing ingredients used shall immediately and conspicuously precede or follow, or in part precede and in part follow, such name, without intervening written, printed, or other graphic matter.

Federal Meat Inspection

The Federal Meat Inspection Act of 1907, as amended in 1938 and 1959 provided for the inspection and control of all meats and meat products, (including cattle, sheep, goats, swine, and in a restricted way horses), intended for interstate commerce or foreign trade.* The

*In December, 1967, the Federal Meat Inspection Act was amended to require that all states be given 2 years (or 3 years if they can show progress) to bring their meat sanitation standards up to Federal requirements.

immediate purpose and effect of the Federal meat inspection law was to prevent interstate or foreign commerce in contaminated or unwholesome meat products. Under this law, federal meat inspectors and employees inspect and supervise the sanitary conditions of the establishment in which the animals are confined or slaughtered or in which meat products are prepared, handled or stored; make ante-mortem and post-mortem inspections for disease conditions; inspect and supervise the manufacture of meat products or any food articles containing meat, and operate laboratories for the examination and analysis of meat and meat products.

What the Federal Government does in relation to meat and meat products to be used for interstate and foreign commerce, the individual states, cities, and counties do for meat and meat products to be used only for intrastate or local consumption. There is a close cooperative understanding usually between Federal and local sanitary workers.

The first essential of a good meat inspection service is to concentrate all slaughtering in central abbatoirs. This simplifies inspection and sanitary control and protects the consumer. This method is only partially realized in the United States.

The purpose of a meat inspection service is to:

1. Eliminate diseased or otherwise unsound meat.

2. Require cleanliness and sanitary precautions in the preparations and process of foods composed wholly or partially of meat.

3. Prevent the use of harmful dyes, preservatives, chemicals or other deleterious substances, and false misleading labels and statements.

Meat inspection includes the following activities:

a. The inspection of establishments.
b. Ante-mortem inspections of animals.
c. Post-mortem inspections and stamping of meat.
d. Inspection of meat products.
e. Inspection of meat and meat products in butcher shops and retail distributing points.
f. Inspection of transportation and storage facilities in the process of production and distribution of meat and meat products.

A food which contains product derived from cattle, sheep, swine, goats, or horses, but which is not amenable to the Meat Inspection Act is subject to the Federal Food, Drug, and Cosmetic Act if in interstate or foreign commerce.

Meat is exempt from the provision of the Federal Food, Drug and Cosmetic Act to the extent of the application, or the extension thereto, of the Meat-Inspection Act.

Meat Inspection

Among the most elaborate and detailed regulations for the Sanitary Control of Meat are those governing Federal meat inspection by the Meat Inspection Division of the Agricultural Research Service of the U.S. Department of Agriculture. The regulations cited below from the Code of Federal Regulations of 1959 governing meat inspection are, for the most part, as applicable to state or municipal administration as for the Federal.

The Federal meat regulations do not require permits for operation as do state and local government, they require only approved application for inspection service. The Federal meat regulations define no penalties for violations as do state and local regulations, therefore the Division of Meat Inspection of the Agricultural Research Service utilizes the services of the Federal Food and Drug Administration which operates under the Federal Food, Drug and Cosmetic Act and has the power to seize meats produced under conditions violating Federal regulations.

Definitions

Meat. The edible part of the muscle of cattle, sheep, swine, or goats which is skeletal or

which is found in the tongue, in the diaphragm, in the heart, or in the esophagus, with or without the accompanying and overlying fat, and the portions of bone, skin, sinew, nerve, and blood vessels which normally accompany the muscle tissue and which are not separated from it in the process of dressing. It does not include the muscle found in the lips, snout, or ears.

Meat byproduct. Any edible part other than meat which has been derived from one or more cattle, sheep, swine, or goats.

Product. Any part or all of meat, byproduct, and meat food product.

Meat food product. Any article of food, or any article intended for or capable of being used as human food which is derived or prepared, in whole or in substantial and definite part, from any portion of any cattle, sheep, swine, or goat, except such articles as organotherapeutic substances, meat juice, meat extract, and the like, which are only for medicinal purposes and are advertised only to the medical profession.

Carcass. All parts, including viscera, of a slaughtered animal that are capable of being used for human food.

"U.S. Inspected and condemned." or any authorized abbreviation thereof. The carcass, viscera, part of carcass, meat, meat byproduct, or meat food product so marked or identified, is unsound, unhealthful, unwholesome, or otherwise unfit for human food.

"U.S. retained." The carcass, viscera, part of carcass, meat, meat byproduct, or meat food product, or other article so marked or identified is held for further examination by an inspector to determine its disposal.

"U.S. suspect." The animal so marked is suspected of being affected with a disease or condition which may require its condemnation, in whole or in part, when slaughtered, and is subject to further examination by an inspector to determine its disposal.

"U.S. condemned." The animal so marked has been inspected and found to be in a dying condition, or to be affected with any other condition or disease that would require condemnation of its carcass.

Immediate container, or true container. The unit can, pot, tin, canvass, or other receptacle or covering in which product is customarily shipped.

Shipping container, or outside container. The box, bag, barrel, crate, or other receptacle or covering inclosing any product packed in one or more immediate or true containers.

"U.S. passed for cooking." The meat and meat byproducts so marked have been inspected and passed on condition that they be rendered into lard, rendered pork fat, or tallow, or otherwise cooked by a method approved by the Director of Division.

"U.S. passed for refrigeration." The meat and meat byproducts so identified have been inspected and passed on condition that they be refrigerated or otherwise handled as prescribed for diseased carcasses or by a method approved by the Director of Divison.

"Inspected and passed," or "U.S. inspected and passed," or "U.S. inspected and passed by Department of Agriculture," or any authorized abbreviations thereof. The meat, meat byproduct, or meat food products so marked have been inspected and passed under Federal regulations, and at the time they were inspected, passed, and so marked they were found to be sound, healthful, wholesome, and fit for human food.

Establishments requiring inspection. Every establishment in which cattle, sheep, swine, or goats are slaughtered for transportation or sale as articles of interstate or foreign commerce, or in which meat, meat byproducts, or meat food products of, or derived from, cattle, sheep, swine, or goats are, wholly or in part, canned, cooked, cured, smoked, salted, packed, rendered, or otherwise prepared for transportation or sale as articles of interstate or foreign commerce, which are capable of being used as food for man, shall have inspection

except as expressly exempted.

Animals and product entering inspected establishments. All cattle, sheep, swine, and goats and all products entering an establishment at which inspection is required, and all products prepared, in whole or in part, therein, shall be inspected, handled, prepared, marked, and labeled as required by the regulations.

Horse slaughtering establishments requiring inspection. Every establishment in which horses are slaughtered for transportation or sale as articles of interstate or foreign commerce, or in which carcasses, parts of carcasses, meat, meat byproducts, or meat food products of, or derived from, horses are, wholly or in part, canned, cured, smoked, salted, packed, rendered or otherwise prepared for transportation or sale as articles of interstate or foreign commerce, which are capable of being used as food for man, shall have inspection in accordance with the terms prescribed.

The slaughter of horses and the preparation and handling of the meat and meat food products thereof shall be conducted in establishments separate and apart from any establishment in which cattle, sheep, swine, or goats are slaughtered, or the meat or meat food products thereof are prepared or handled.

Application for inspection or exemption. The proprietor or operator of each establishment shall make application to the Director of Division for inspection or for exemption from inspection.

Inspection; drawings, information to be furnished, subsidiary establishments, notice of grant of inspection, false statements.

a. Triplicate copies of complete drawings, with specifications, consisting of floor plans showing the locations of such features as the principal pieces of equipment, floor drains, principal drainage lines, hand-washing basins, and hose connections for clean-up purposes; roof plans; elevations; cross and longitudinal sections of the various buildings showing such features as principal pieces of equipment, heights of ceilings, conveyor rails, and character of floors and ceilings; and a plot plan showing such features as the limits of the plant's premises, locations in outline of buildings on the premises, cardinal points of the compass, and roadways and railroads serving the plant, properly drawn to scale, shall accompany applications for inspection. Applicants for inspection may request information from the Director of Division concerning the requirements before submitting plans.

b. Each application shall specify the names, addresses, and forms of organization of subsidiaries for which meat inspection is requested.

c. Notice in writing shall be given to each applicant granted inspection, specifying the establishment to which the same applies.

d. The Director of Division is authorized to determine whether applications for inspection or for exemption from inspection shall be granted or refused, and to revoke his prior approval of any application if he determines that any false statement were made in such application.

Exemptions. a. Retail butchers and retail dealers in product, supplying their customers as provided in the Meat Inspection Act, upon making application, may be exempted from inspection. To each one so exempted, a numbered certificate of exemption shall be furnished. No certificate of exemption shall be issued unless all the premises on which the products are prepared and handled be maintained in a sanitary condition. Failure by certificate holders to maintain sanitary conditions or to conform to such of the regulations as apply to them shall be cause for withdrawal of exemption and the cancellation of certificates. Such exempted establishments shall conform to the same regulations as govern official establishments* to the

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*Official Establishment is one where any slaughtering, meat canning, curing, smoking, salting, packing, rendering, is carried on and at which inspection is maintained under these regulations.

extent that such regulations are applicable, including but not limited to those regulations regarding labeling, the use of dyes, chemical, and preservatives, and the prescribed treatment of pork to destroy trichinae.

b. On request of the Director of Division, or an employee designated by him, an exempted establishment shall furnish such information concerning its business and operations as has a bearing on the exemption of the establishment from inspection.

c. The Director of Divsion is authorized to withdraw exemption from any exempted establishment which fails to comply with any applicable provision of the Meat-Inspection Act or of the regulations made pursuant thereto.

d. A certificate of exemption will be issued only in one name at one location. A certificate will not be issued if any business be transacted at the location in the name of anyone other than the applicant for the certificate of exemption, for example, in the name of a parent company, subsidiary, or tenant of the applicant.

Exemption; holders of, limited to supplying own customers. No establishment holding a certificate of exemption shall use the same for any purpose except to supply its own customers, as provided in the Meat-Inspection Act.

Shipments of farm-dressed meat. The carcasses and products of animals slaughtered by any farmer on the farm: Provided, they can be identified as such and are sound, healthful, wholesome, and fit for human food, and otherwise meet the requirements of the applicable regulations, may be transported in interstate or foreign commerce. A farmer need not apply for exemption from inspection in order to procure the transportation of such carcasses and products.

Inspections for violations. The issuance of certificates of exemption shall be conditioned on the granting of permission by the holder thereof to inspectors to make inspections to ascertain whether any of the regulations have been violated. Inspectors shall make inspections to ascertain whether any of the regulations applying to retail butchers, retail dealers, farmers, or other persons have been violated.

Official numbers; subsidiary establishments. To each establishment granted inspection an official number shall be assigned. Such number shall be used to identify all inspected and passed products prepared in the establishment. More than one number shall not be assigned to an establishment.

Two or more official establishments under the same ownership or control may be granted the same official number, provided a serial letter is added in each case to identify each establishment and the products thereof.

When inspection has been granted to a person at an establishment, it shall not be granted to any other person at the same establishment, except that a subsidiary of the grantee, doing any of the business described in "Establishments requiring inspection" may apply for and receive inspection.

Separation of official from unofficial establishment. Each official establishment shall be separate and distinct from any other official establishment, from any unofficial establishment in which any product is handled, and from any other unofficial establishment at the discretion of the Director of Division.

Inspection shall not be inaugurated in any building any part of which is used as living quarters unless the part for which inspection is requested be separated from such quarters by floors, walls and ceilings of solid concrete, brick, or similar material, and the floors, walls, and ceilings are without opening that directly or indirectly communicates with any part of the building used as living quarters.

Sanitation and adequate facilities. Inspection shall not be begun if an establishment be not

in a sanitary condition nor unless the establishment agrees to maintain such condition and provides adequate facilities for conducting such inspection.

Inauguration of inspection. When an application for inspection is granted, the inspector in charge shall, at or prior to the inauguration of inspection, inform the proprietor or operator of the establishment of the requirements of these regulations. If the establishment, at the time inspection is inaugurated, contains any product which has not theretofore been inspected, passed and marked in compliance with the regulations, the identity of the same shall be maintained, and it shall not be transported or offered for transportation in interstate or foreign commerce, or otherwise dealt with as inspected and passed under the regulations. The establishment shall adopt and enforce all necessary measures, and shall comply with all such directions as the inspector in charge may prescribe, for carrying out the purposes of this section.

Withdrawal of inspection for violations of regulations. The Director of Divsion is authorized to withdraw inspection from any official establishment which fails to comply with any provision of the Meat-Inspection Act or of the regulations made pursuant thereto.

Reports of violations of regulations. Inspectors and other division employees shall report to the inspector in charge of all violations and failures of which they have knowledge, and the inspector in charge shall report to the Director of Division.

Designation of inspector in charge and assistants. The Director of Division shall designate an inspector in charge of the inspection at each official station,* and assign to said inspector such assistants as may be necessary.

Division employees to have access to establishments at all times. For the purpose of any examination or inspection necessary to enforce any of the provisions of the regulations, division employees shall have access at all times, by day or night, whether the establishment be operated or not, to every part of any official establishment in which they are assigned.

Badge as identification of inspectors. Each division employee will be furnished with a numbered official badge, which he shall not allow to leave his possession, and which he shall wear in such manner and at such times as the Director of Division may prescribe. This badge shall be sufficient identification to entitle him to admittance at all regular entrances and to all parts of the establishment and premises to which he is assigned.

Assignment of inspectors where members of family employed; soliciting employment. Except as specifically authorized by the Director of Division, no division employee shall be detailed for duty at an establishment where any member of his family is employed by the establishment, nor shall any inspector in charge or other employee acting in a supervisory capacity be continued on duty at an official station where any member of his family is employed by any establishment under his jurisdiction. Division employees are forbidden to solicit, for any person, employment at any official establishment, or by any officer, manager, or employee thereof.

Facilities for division employees. Furnished office room, including light, heat and janitor service, shall be provided by official establishments, rent free, for the exclusive use for official purposes of the inspector and other division employees assigned thereto. The room or rooms set apart for this purpose shall meet with the approval of the inspector in charge and shall be conveniently located, properly ventilated, and provided with lockers suitable for the protection and storage of division supplies and with facilities suitable for division employees to change clothing. Laundry service for inspectors' outer work clothing shall be provided by establishments.

Hours of operation of official establishments. Each official establishment shall inform the

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*Official Station is one or more of official establishments included under a single supervision.

inspector in charge, or his assistant, when work in each department has been concluded for the day, and of the day and hour when work will be resumed therein. Whenever any product is to be overhauled or otherwise handled in an official establishment during unusual hours, the establishment shall, a reasonable time in advance, notify the inspector in charge, or his assistant, of the day and hour when such work will be commenced, and such articles shall not be so handled except after such notice has been given. No department of an official establishment shall be operated except under the supervision of a division employee. All slaughtering of animals and preparation of products shall be done within reasonable hours, and with reasonable speed, the facilities of the establishment being considered. No shipment of any product shall be made from an official establishment until after due notice has been given to the inspector in charge or his assistant.

Designation of days and hours of operation by inspector in charge. When one inspector is detailed to conduct the work at two or more official establishments where few animals are slaughtered or where but a small quantity of any product is prepared, the inspector in charge may designate the hours of the day and the days of the week during which such establishments may be operated.

Overtime work of meat inspection employees. The management of an official establishment, an importer, or an exporter desiring to work under conditions which will require the services of an employee of the division on any Saturday, Sunday, or holiday, or for more than 8 hours on any other day, shall, sufficiently in advance of the period of overtime, request the inspector in charge or his assistant to furnish inspection services during such overtime period, and shall pay the Administrator therefor an amount sufficient to reimburse the Service for the cost of the inspection services so furnished. It will be administratively determined from time to time which days constitute holidays.

Facilities and conditions to be provided by establishment. When required by the Director of Division or the inspector in charge, the following facilities and conditions, and such others as may be essential to efficient conduct of inspection and maintenance of sanitary conditions, shall be provided by each official establishment:

(a) Satisfactory pens, equipment, and assistants for conducting antemortem inspection and for separating, marking, and holding apart from passed animals those marked "U.S. suspect" and those marked "U.S. condemned". Pens, alleys, and runways shall be paved, drained, and supplied with adequate hose connections for cleanup purposes. Sufficient light shall be provided for the inspection.

(b) Sufficient natural light and abundant artificial light at all places and such times of the day when natural light may not be adequate for proper conduct of inspection. Rooms shall be kept sufficiently free of steam and vapors for inspection to be properly made. Equipment or substances which generate gases or odors shall not be used except as specifically permitted by the Director of Division.

(c) Racks, receptacles, or other suitable devices for retaining such parts as the head, tongue, tail, thymus gland, and viscera, and all parts and blood to be used in the preparation of meat food products or medical products, until after the post-mortem examination is completed, in order that they may be identified in case of condemnation of the carcass; equipment, trucks, and receptacles for the handling of viscera of slaughtered animals so as to prevent contact with the floor; trucks, racks, marked receptacles, tables, or other necessary equipment for the separate and sanitary handling of carcasses or parts passed for cooking.

(d) Tables, benches, and other equipment on which inspection is performed, of such design, material, and construction as to enable division employees to conduct their inspection in a ready, efficient, and cleanly manner.

(e) Watertight metal trucks or receptacles for holding and handling diseased carcasses and parts, so constructed as to be readily cleaned; such trucks or receptacles to be marked in a conspicuous manner with the phrase "U.S. condemned" in letters not less than 2 inches high and, when required by the inspector in charge, to be equipped with facilities for locking or sealing.

(f) Adequate arrangements, including liquid soap and cleansers, for cleansing and disinfecting hands, for sterilizing all implements used in dressing diseased carcasses, floor and such other articles and places as may be contaminated by diseased carcasses or otherwise.

(g) In establishments in which slaughtering is done, rooms, compartments, or specially prepared open places, to be known as "final inspection places," at which the final inspection of retained carcasses may be conducted. Competent assistants for handling retained carcasses and parts shall be provided by the establishment. Final inspection places shall be adequate in size and their rail arrangement and other equipment shall be sufficient to prevent carcasses and parts passed for food or cooking, from being contaminated by contact with condemned carcasses or parts. They shall be equipped with hot water, lavatory, sterilizer, tables, and other equipment required for ready, efficient, and sanitary conduct of the inspection. The floors shall be of such construction as to facilitate the maintenance of sanitary conditions and shall have proper drainage connections, and when the final inspection place is part of a larger floor, it shall be separated by a curb, railing, or otherwise.

(h) Rooms, compartments, and receptacles in which carcasses and product may be held for further inspection. These shall be in such number and in such locations as the needs of the inspection in the establishment may require. They shall be equipped for secure locking and be held under locks furnished by the Department*, the keys of which shall not leave the custody of division employees. Every such room, compartment, or receptacle shall be marked conspicuously with the phrase "U.S. retained" in letters not less than 2 inches high. Rooms or compartments for these purposes shall be secure and susceptible of being kept clean, including a sanitary disposal of the floor liquids.

(i) Adequate facilities, including denaturing materials, for the proper disposal of condemned articles in accordance with the regulations. Tanks or other rendering equipment which, under the regulations must be sealed, shall be properly equipped for sealing as may be specified by the Director of the Division.

(j) Docks and receiving rooms, to be designated by the establishment, with the approval of the inspector in charge, for the receipt and inspection of all products.

(k) Suitable lockers in which brands bearing the inspection legend shall be kept when not in use. All such lockers shall be equipped for locking with locks to be supplied by the Department, the keys of which shall not leave the custody of division employees.

Inspectors to furnish implements and maintain hands and implements in sanitary condition. Inspectors shall furnish their own work clothing and implements, such as knives, steels, flashlights, and triers, for conducting inspection and shall cleanse their hands and implements as prescribed.

Examination and specifications for equipment and sanitation prior to granting inspection. Prior to the inauguration of inspection, an examination of the establishment and premises shall be made by a division employee and the requirements for sanitation and the necessary facilities for inspection specified.

Drawings and specifications to be furnished in advance of construction. Triplicate copies of drawings and specifications for remodeling plants of official establishments and for new structures shall be submitted to the Director of Division and approval obtained for the plants in advance of construction.

Establishments; sanitary condition; requirements. Official establishments and premises on or in which any product is prepared or handled by or for persons to whom certificates of exemption have been issued, shall be maintained in sanitary condition as follows:

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*U.S. Department of Agriculture.

There shall be abundant light, both natural and artificial, of good quality and well distributed, and sufficient ventilation for all rooms and compartments to insure sanitary condition.

There shall be an efficient drainage and plumbing system for the establishment and premises, and all drains and gutters shall be properly installed with approved traps and vents.

The water supply shall be ample, clean, and potable, with adequate facilities for its distribution in the plant and its protection against contamination and pollution. Every establishment shall make known, and whenever required, shall afford opportunity for inspection of the source of its water supply, the storage facilities, and the distribution system. Equipment using potable water shall be so installed as to prevent back-siphonage into the potable water system. Nonpotable water is permitted only in those parts of official establishments where no edible product is handled or prepared, and then only for limited purposes such as ammonia condensers not connected with the potable water supply, in vapor lines serving inedible product rendering tanks, in connection with equipment used for hashing and washing inedible products preparatory to tanking, and in sewer lines for moving heavy solids in the sewage. Nonpotable water is not permitted for washing floors, areas, or equipment involved in trucking materials to and from edible products departments, nor is it permitted in hog scalding vats, dehairing machines, or vapor lines serving edible product rendering equipment, or for clean-up of shackling pens, bleeding areas, or runways within the slaughtering department. In all cases, nonpotable water lines shall be clearly identified and shall not be cross-connected with the potable water supply unless this be necessary for fire protection and such connection is of a type with an adequate break to assure against accidental contamination, and is approved by local authorities and by the Director of Division.

Inspectors in charge may permit the reuse of water in vapor lines leading from deodorizers used in the preparation of lard and similar edible product and in equipment used for the chilling of canned product after retorting, provided the reuse is for the identical original purpose and the following precautions are taken to protect the water that is reused:

All pipe lines, reservoirs, tanks, cooling towers, and like equipment employed in handling the reused water are so constructed and installed as to facilitate their cleaning and inspection.

Complete draining and disposal of the reused water, effective cleaning of the equipment, and renewal with fresh potable water is accomplished at such intervals as may be necessary to assure an acceptable supply of water for the purpose intended.

Effective chlorination (not less than approximately 1 part per million of residual chlorine at any point within the cooling system) of the reused water utilized for cooling canned product is maintained but with the understanding that chlorination alone is not to be relied upon entirely or to be accepted in lieu of the requirements listed in above.

An ample supply of water at not less than 100° F. shall be furnished and used for the cleaning of inspection equipment and other equipment, floors, walls, and the like, which are subject to contamination by the dressing or handling of diseased carcasses, their viscera and parts. Whenever necessary to determine compliance with this requirement, conveniently located thermometers shall be installed to show the temperature of the water at the point of use.

Hot water for cleaning rooms and equipment other than those mentioned above shall be delivered under pressure to sufficient convenient outlets and shall be of such temperature as to accomplish a thorough clean-up.

The floors, walls, ceilings, partitions, posts, doors, and other parts of all structures shall be of such materials, construction, and finish as will make them susceptible of being readily and thoroughly cleaned. The floors shall be kept watertight. The rooms and compartments used for edible products shall be separate and distinct from those used for inedible products.

The rooms and compartments in which any product is prepared or handled shall be free

from dust and from odors from dressing and toilet rooms, catchbasins, hide cellars, casing rooms, inedible tank and fertilizer rooms, and livestock pens.

Every practicable precaution shall be taken to exclude flies, rats, mice, and other vermin from establishments. The use of poisons for any purpose in rooms or compartments where any unpacked product is stored or handled is forbidden, except under such restrictions and precautions as the Director of Division may prescribe. The use of bait poisons in hide cellars, inedible compartments, outbuildings, or similar places, or in storerooms containing canned or tierced products is not forbidden but only those approved by the Director of Division may be used. So-called rat viruses shall not be used in any part of an establishment or the premises thereof.

Dogs and cats shall be excluded from establishments.

Sanitary facilities and accommodations; specific requirements. Adequate sanitary facilities and accommodations shall be furnished by every official establishment. Of these the following are specifically required:

(a) Dressing rooms, toilet rooms, and urinals shall be sufficient in number, ample in size, and conveniently located. The rooms shall be provided with windows to admit direct, natural light and shall have adequate facilities for artificial light. They shall be properly ventilated, and meet all requirements as to sanitary construction and equipment. They shall be separate from the rooms and compartments in which products are prepared, stored, or handled. Where both sexes are employed, separate facilities shall be provided.

(b) Modern lavatory accommodations, including running hot and cold water, soap, towels, etc. These shall be placed in or near toilet and urinal rooms and also at such other places in the establishment as may be essential to assure cleanlinesss of all persons handling product.

(c) Toilet soil lines shall be separate from house drainage lines to a point outside the buildings and drainage from toilet bowls and urinals shall not be discharged into a grease catchbasin.

(d) Properly located facilities for cleansing and disinfecting utensils and hands of all persons handling any product.

Equipment to be easily cleaned; that for inedible products to be marked. Equipment and utensils used for preparing, processing, and otherwise handling any product shall be of such materials and construction as will make them susceptible of being readily and thoroughly cleaned and such as will insure strict cleanliness in the preparation and handling of all products. So far as is practicable, such equipment shall be made of metal or other impervious material. Trucks and receptacles used for inedible materials shall be of similar construction and shall bear some conspicuous and distinctive mark, and shall not be used for handling edible products.

Scabbards for knives. Scabbards and similar devices for the temporary retention of knives, steels, triers, etc., by workers and others at inspected establishments shall be constructed of rust-resisting metal or other impervious material, shall be of a type that may be readily cleaned, and shall be kept clean.

(a) Rooms, compartments, etc., to be clean and sanitary. Rooms, compartments, places, equipment, and utensils used for preparing, storing, or otherwise handling any product, and all other parts of the establishment, shall be kept clean and in sanitary condition. There shall be no handling or storing of materials which create an objectionable condition in rooms, compartments, or places where product is prepared, stored, or otherwise handled.

Operations, procedures, rooms, clothing, utensils, etc., to be clean and sanitary. Operations and procedures involving the preparation, storing or handling of any product shall be strictly in accord with cleanly and sanitary methods.

Rooms and compartments in which inspections are made and those in which animals are slaughtered or any product is processed or prepared shall be kept sufficiently free of steam and vapors to enable division employees to make inspections and to insure cleanly operations. The walls, ceilings, and overhead structures of rooms and compartments in which product is prepared, handled, or stored shall be kept reasonably free from moisture.

Butchers and others who dress or handle diseased carcasses or parts shall, before handling or dressing other carcasses or parts, cleanse their hands with liquid soap and hot water, and rinse them in clean water. Implements used in dressing diseased carcasses shall be thoroughly cleansed in boiling water, or in a prescribed disinfectant followed by rinsing in clean water. The employees of the establishment who handle any product shall keep their hands clean, and in all cases, after visiting the toilet rooms or urinate shall wash their hands before handling any product or implements used in the preparation of product.

Aprons, frocks, and other outer clothing worn by persons who handle any product shall be of material that is readily cleansed and only clean garments shall be worn.

Such practices as spitting on whetstones; spitting on the floor; placing skewers, tags, or knives in the mouth; inflating lungs or casings, or testing with air from the mouth such receptacles as tierces, kegs, casks, and the like, containing or intended as containers of any product, are prohibited. Only mechanical means may be used for testing. Care shall be taken to prevent the contamination of products with perspiration, hair, cosmetics, medicaments and the like.

Protective coverings for product. Inspectors in charge shall require the use of such protective coverings for product as it is distributed from official establishments as will afford adequate protection for the product against dust, dirt, insects, and the like, considering the means intended to be employed in transporting the product from the establishment.

Slack barrels and similar containers and vehicles and cars for product; paper in contact with product. When necessary to avoid contamination of product with wood splinters and the like, slack barrels and similar containers, and vehicles and cars shall be lined with suitable material of good quality before packing.

Slack barrels and similar containers and vehicles and cars in which any product is transported shall be kept in a clean and sanitary condition.

Paper used for covering or lining slack barrels and similar containers and vehicles and cars shall be of a kind which does not tear during use but remains intact when moistened by the product and does not disintegrate.

Burlap wrapping for meat; meat wrapped in, to be previously wrapped in paper or cloth. Since burlap used without any other material as a wrapping for meat deposits lint on the meat and does not sufficiently protect it from outside contamination, the use of burlap as a wrapping for meat will not be permitted unless the meat be first wrapped with a good grade of paper or cloth of a kind which will prevent contamination with lint or other foreign matter.

Second-hand tubs, barrels, other containers and tank cars; inspection and cleaning. (a) Second-hand tubs, barrels, and boxes intended for use as containers of any product shall be inspected when received at the establishment and before they are cleaned. Those showing evidence of misuse rendering them unfit to serve as containers for food products shall be rejected. The use of those showing no evidence of previous misuse may be allowed after they have been thoroughly and properly cleaned. Steaming after thorough scrubbing and rinsing, is essential to cleaning tubs and barrels.

(b) Interiors of tank cars about to be used for the transportation of any product shall be carefully inspected for cleanliness even though the last previous content were edible. Lye and soda solutions used in cleaning must be thoroughly removed by rinsing with clean water. In their examination division employees shall enter the tank with a light and examine all parts of the interior.

Inedible operating and storage rooms; outer premises, docks, drive-ways, approaches, pens, alleys, etc.; fly-breeding material nuisances. All operating and storage rooms and departments of official establishments used for inedible materials shall be maintained in acceptably clean condition. The outer premises of every official establishment, embracing docks and areas where cars and vehicles are loaded, and the driveways, approaches, yards, pens, and alleys shall be properly paved and drained and kept in clean and orderly condition. All catchbasins on the premises shall be of such construction and location and shall be given such attention as will insure their being kept in acceptable condition as regards odors and cleanliness. Catchbasins shall not be located in departments where product is prepared, handled, or stored. The accumulation on the premises of establishments of any material in which flies may breed, such as hog hair, bones, paunch contents, or manure, is forbidden. No nuisance shall be allowed in any establishment or on its premises.

Employment of diseased persons. No establishment shall employ, in any department where any product is handled or prepared, any person affected with tuberculosis or other communicable disease in a transmissible stage.

Tagging insanitary equipment, utensils, rooms or compartments. When, in the opinion of a division employee, any equipment utensil, room, or compartment at an official establishment is unclean or its use would be in violation of any of the regulations, he will attach a "U.S. Rejected" tag thereto. No equipment, utensil, room, or compartment so tagged shall again be used until made acceptable. Such tag so placed shall not be removed by anyone other than a division employee.

Ante-mortem inspection in pens of official establishments; suspects. An ante-mortem examination and inspection shall be made of all cattle, sheep, swine, and goats about to be slaughtered in an official establishment before their slaughter shall be allowed. Such inspection shall be made on the day of slaughter.

Such ante-mortem inspection shall be made in pens on the premises of the establishment in which the animals are about to be slaughtered. When the holding pens of an official establishment are located in a public stock yard and are reserved for the exclusive use of the establishment, such pens shall be regarded as part of the premises of that establishment and the establishment shall be responsible therein for all requirements.

Every animal required to be marked as a suspect on ante-mortem inspection in the pens of an official establishment shall be set apart, and, except as hereinafter provided, shall be slaughtered separately from other animals at that establishment unless disposed of as otherwise provided.

Animals suspected of being diseased; disposition of on post-mortem inspection or otherwise; marking suspects, temperatures where disease suspected. (a) Any animal which, on ante-mortem inspection, does not plainly show, but is suspected of being affected with, any disease or condition that may cause condemnation of the carcass on post-mortem inspection, and any animal which shows, on ante-mortem inspection, any disease or condition that would cause condemnation of only part of the carcass on post-mortem inspection, shall be so marked as to retain its identity as a suspect until final post-mortem inspection, when the carcass shall be marked and disposed of as provided.

(b) All animals required to be treated as suspects, or to be marked as suspects, or to be marked so as to retain their identity as suspects, shall be marked by or under the supervision of a division employee "U.S. suspect," or with other distinctive mark or marks to indicate that they are suspects. No such mark shall be removed except by a division employee.

(c) Each animal marked "U.S. suspect" on ante-mortem inspection, and animals treated as suspects, when presented for slaughter shall be accompanied with a Form MI 402-2, on which shall be recorded the suspect tag number and any other identifying tag numbers present and a brief description of the animal and of the disease or condition for which the animal was classed as a suspect, including its temperature when the temperature of such animal might have a bearing on the disposition of the carcass on post-mortem inspection.

(d) Any swine having a temperature of 106° F. or higher and any cattle, sheep or goats having a temperature of 105° F. or higher shall be marked "U.S. Condemned". In case of doubt as to the cause of the high temperature, or when for other reasons such action appears warranted, any such animals may be held for a reasonable time, under the supervision of a Division employee, for further observation and taking a temperature before final disposition of such animals is determined.

(e) When any animal tagged "U.S. suspect" is released for any purpose or reason, as provided, the tag shall be removed by a division employee and his action reported to the inspector in charge.

Marking animals "U.S. condemned" found diseased or in dying condition. (a) All animals plainly showing on ante-mortem inspection any disease or condition that would cause condemnation of their carcasses on post-mortem inspection shall be marked "U.S. condemned" and disposed of in accordance with the regulations.

(b) Animals received for slaughter and found in a dying condition on premises of an official establishment shall be marked "U.S. condemned" and disposed of in accordance with regulations for "Disposition of Condemned Animals".

(c) Reactors to the tuberculin test, required by this section to be condemned, should be autopsied and the findings made the subject of a special report.

(d) Any animal found in a comatose or semi-comatose condition or affected with any condition not otherwise covered in this part, which would not warrant release of the animal for slaughter for food shall be marked "U.S. condemned" and disposed of except that such animal may be set apart and held for further observation or treatment under Division or other responsible official supervision.

Cripples and downers. All seriously crippled animals and animals commonly termed "downers," if not marked "U.S. condemned," as required elsewhere in this part, shall be marked and treated as suspects.

Immature animals. Animals which are offered for ante-mortem inspection under this part, and which are regarded as immature, shall be marked "U.S. suspect" and, if slaughtered, the disposition of their carcasses shall be determined by the post-mortem findings in connection with the ante-mortem conditions. If not slaughtered as suspects, such animals shall be held under Division or other responsible official supervision, and after sufficient development may be released for slaughter, or may be released for any other purpose, provided they have not been exposed to any infectious or contagious disease.

Animals showing symptoms of anaplasmosis, leptospirosis, listerellosis, parturient paresis, rabies, railroad sickness, or tetanus. (a) All animals showing on ante-mortem inspection symptoms of anaplasmosis, leptospirosis, listerellosis, parturient paresis, rabies, railroad sickness, or tetanus shall be marked "U.S. condemned" and disposed of in accordance with regulations for "Disposition of Condemned Animals," except that cattle showing symptoms of anaplasmosis, leptospirosis, listerellosis, parturient paresis, or railroad sickness may be set apart and held for treatment under Division or other responsible official supervision. If, at the expiration of the treatment period, animals upon examination are found to be free from disease, they may be released for any purpose in accordance with the regulations for "Disposition of Condemned Animals," except that when released for slaughter at the official establishment, animals which have been previously affected with listerellosis shall be marked "U.S. suspect".

(b) Animals which have reacted to a test for leptospirosis, but which show no symptoms of the disease, shall be marked "U.S. suspect".

Hog cholera; swine injected with hog cholera virus. (a) All hogs plainly showing on ante-mortem inspection that they are affected with hog cholera shall be marked "U.S. condemned" and disposed of.

(b) If a hog has a temperature of 106° F. or higher, and is of a lot in which there are symptoms of hog cholera, in case of doubt as to the cause of the high temperature, after being marked for identification, it may be held for a reasonable time, under the supervision of a Division employee for further observation and taking of temperature. Any hog so held shall be reinspected on the day it is slaughtered. If, upon such reinspection, or, when not held for further observation and taking of temperature, then on the original inspection, the hog has a temperature of 106° F. or higher, it shall be condemned and disposed of.

(c) All hogs, even though not themselves marked as suspects which are of lots one or more of which have been condemned or marked as suspects for hog cholera, shall, so far as possible, be slaughtered separately and apart.

(d) A hog suspected of being affected with hog cholera may be set apart and held for treatment under Division or other responsible official supervision. If at the expiration of the treatment period, the animal, upon examination, be found to be free from disease, it may be released for any purpose, including slaughter.

(e) Swine, other than hyperimmune swine, shall be condemned on ante-mortem inspection if offered for slaughter within 28 days after injection with hog-cholera virus.

(f) Swine, other than hyperimmune swine, offered for slaughter after 28 days following injection with hog-cholera virus shall be given ante-mortem inspection in conformity with these regulations without reference to the injected virus.

(g) Hyperimmune swine shall be condemned on ante-mortem inspection if offered for slaughter within 10 days after hyperimmunization.

(h) Hyperimmune swine offered for slaughter after 10 days following hyper-immunization shall be given ante-mortem inspection in conformity with these regulations without reference to the injected virus.

Epithelioma of the eye of cattle. (a) Any animal found on ante-mortem inspection to be affected with epithelioma of the eye and of the orbital region in which the eye has been destroyed or obscured by neoplastic tissue and which shows extensive infection, suppuration, and necrosis, usually accompanied with foul odor, or any animal affected with epithelioma of the eye or of the orbital region which, regardless of extent, is accompanied with cachexia shall be marked "U.S. condemned" and disposed of.

(b) Any animal found on ante-mortem inspection to be affected with epithelioma of the eye or of the orbital region to a lesser extent than in (a) shall be marked "U.S. suspect" and disposed of as provided in these regulations.

Animals affected with anthrax; cleaning and disinfection of infected livestock pens and driveways. (a) Any animal found on ante-mortem inspection to be affected with anthrax shall be marked "U.S. condemned" and disposed of.

(b) No animals of a lot in which anthrax is found on ante-mortem inspection shall be presented for post-mortem inspection until it has been determined by a careful ante-mortem inspection that no infected animal remains in the lot. Apparently healthy animals other than hogs shall be held as provided for in paragraph (c) of this section. If desired, all apparently healthy animals of the lot may be segregated and held for treatment by a competent veterinarian under Division or other responsible official supervision. No anthrax vaccine (live organisms) shall be used on the premises of an official establishment.

(c) Apparently healthy animals of a lot of cattle, calves, sheep, or goats in which anthrax is detected, and animals which have been treated with anthrax biologicals which do not contain living anthrax organisms, shall not be presented for post-mortem inspection in less than 21 days following the last treatment or the last death. Treatment with anthrax vaccine (live organisms) must be elsewhere than on the official premises and subject to the conditions stated in paragraph (d) of this section.

(d) Animals which have been injected with anthrax vaccines (live organisms) within six weeks, and those bearing evidence of reaction to such treatment, such as inflammation, tumefaction, or edema at the site of the injection, shall be condemned on ante-mortem inspection, or such animals may be held under Division or other responsible official supervision until the expiration of the six-week period and the disappearance of any reaction to the treatment.

(e) When animals are found on ante-mortem inspection to be affected with anthrax, the cleaning and disinfection of exposed livestock pens and driveways of the official establishment shall consist of promptly and thoroughly removing and burning all straw, litter, and manure. This should be followed immediately by a thorough disinfection of the exposed premises by soaking the ground, fences, gates, and all exposed material with a 5 percent solution of sodium hydroxide or commercial lye prepared as outlined herein, or other disinfectant approved by the Director of Division specifically for this purpose.

Cattle affected with anasarca or generalized edema. (a) All cattle found on ante-mortem inspection to be affected with anasarca in advanced stages and characterized by an extensive and generalized edema shall be marked "U.S. condemned" and disposed of.

(b) Cattle found on ante-mortem inspection to be affected with anasarca to a lesser extent than in paragraph (a) of this section shall be marked "U.S. suspect" and disposed of as provided.

(c) An animal suspected of being affected with anasarca may be set apart and held for treatment under Division or other responsible official supervision. If at the expiration of the treatment period the animal upon examination be found to be free from disease, it may be released for any purpose.

Tuberculin test reactors. Animals which are known to have reacted to the tuberculin test and which are to be slaughtered at an official establishment shall be marked and treated as suspects, except that animals bearing an official "USADE Reactor" or similar State reactor tag should not be tagged "U.S. suspect".

Swine erysipelas. (a) All hogs plainly showing on ante-mortem inspection that they be affected with acute swine erysipelas shall be marked "U.S. condemned" and disposed of.

(b) All hogs suspected on ante-mortem inspection of being affected with swine erysipelas shall be marked and treated as suspects and disposed of.

(c) A hog suspected of being affected with swine erysipelas may be set apart and held under Division or other responsible official supervision for treatment. If at the expiration of the treatment period the animal upon examination be found to be free from disease, it may be released for any purpose.

Pregnancy or recent parturition. The slaughter of an animal which has been marked as a suspect on account of advanced pregnancy or on account of having recently given birth to young, and which has not been exposed to any infectious or contagious disease, is not required. Such animal, together with its young, may be released for breeding or dairy purposes, and when released shall be removed promptly from the stockyards or premises of the establishment where inspected. Such animals may be held at the establishment for a period of not less than 10 days. At the completion of this holding period if the animals appear normal and have not been exposed to contagious or infectious disease, they may be released for slaughter or for any other purpose.

Vaccine animals. Vaccine animals with unhealed lesions of vaccinia, accompanied with fever, which have not been exposed to any other infectious or contagious disease, are not required to be slaughtered and may be released for removal from the premises.

Emergency slaughter; inspection prior to. In all cases of emergency slaughter, except as provided herein, the animals shall be inspected immediately before slaughter, whether theretofore inspected or not. When the necessity for emergency slaughter exists, the establishment

shall notify the inspector in charge or his assistant so that such inspection may be made.

Disposition of condemned animals. Except as otherwise provided in this part, animals marked "U.S. condemned" shall be killed by the official establishment, if not already dead. Such animals shall not be taken into an establishment to be slaughtered or dressed; nor shall they be conveyed into any department of the establishment used for edible products; but they shall be disposed of and tanked in the manner provided for condemned carcasses. The "U.S. condemned" tag shall not be removed from, but shall remain on, the carcass until it goes into the tank, at which time the tag may be removed by a Division employee only. The number of such tag shall be reported to the inspector in charge by the inspector who affixed it, and also by the inspector who supervised the tanking of the carcass. Any animal condemned on account of hog cholera, swine erysipelas, vesicular exanthema, vesicular stomatitis, railroad sickness, parturient paresis, anasarca, anaplasmosis, leptospirosis, listerellosis, or inflammatory condition including pneumonia, enteritis, and peritonitis, may be set apart and held for treatment under Division or other responsible official supervision. The "U.S. condemned" tag will be removed by a Division employee either when the animal is released to a responsible official for treatment, or following treatment under Division supervision if the animal be found to be free from disease. When an animal under the provisions of these regulations is to be released for a purpose other than slaughter, the official establishment or the owner of the animal shall first obtain permission for the movement of such animal from the local State or Federal livestock sanitary official having jurisdiction.

Brucellosis-reactor goats. Goats which have reacted to a test for brucellosis shall not be slaughtered in an official establishment.

Vesicular diseases. (a) Immediate notification shall be given to the local, state, and federal livestock sanitary officials having jurisdiction when an animal is found to be affected with a vesicular disease.

(b) No animal under quarantine by state or Federal livestock sanitary officials on account of a vesicular disease will be given ante-mortem inspection.

(c) If no quarantine be invoked, or if a quarantine be invoked and later lifted, ante-mortem inspection shall be as follows:

(1) Any animal affected with vesicular exanthema or vesicular stomatitis in the acute stages, as evidenced by acute and active lesions or an elevated temperature, shall be marked "U.S. condemned" and disposed of.

(2) Any animal affected with vesicular exanthema, or vesicular stomatitis, but which has recovered to the extent that the lesions are in process of healing, the temperature is within normal range, and the animal shows a return to normal appetite and activity, shall be marked "U.S. suspect" and disposed of, except that if desired, such animal may be set apart and held under Division or other responsible official supervision for treatment. If the animal be set aside for treatment, the "U.S. suspect" tag will be removed by a Division employee, either when the animal is released for treatment to a responsible official, or, following treatment while under the custody of a Division employee if the animal be found to be free from disease. Such animal, found to be free from disease, may be released for slaughter or for purposes other than slaughter, provided that in the latter instance, the official establishment or the owner of the animal shall first obtain permission from the local, state, or Federal livestock sanitary official having jurisdiction of the movement of such animal.

Extent and time of post-mortem inspection. A careful post-mortem examination and inspection shall be made of the carcasses and parts thereof of all cattle, sheep, swine, and goats slaughtered at official establishments. Such inspection and examination shall be made at the time of slaughter, except in cases of emergencies as provided.

Organs and parts to be held pending final inspection of carcasses. The head, tongue, tail, thymus gland, and all viscera, and all parts and blood to be used in the preparation of meat food products or medical products, shall be held in such manner as to preserve their identity until after post-mortem examination has been completed, in order that they may be identified

in case the carcass be condemned, passed for cooking or held for refrigeration.

Carcasses and parts in certain instances to be retained. Each carcass, including all detached parts and organs thereof, in which any lesion or other condition is found that might render the meat or any part or organ unfit for food purposes, and which for that reason would require a subsequent inspection, shall be retained by the division employee at the time of inspection. The identity of every such retained carcass, detached part, and organ thereof shall be maintained until the final inspection has been completed. Retained carcasses shall not be washed or trimmed unless authorized by the inspector.

Identification of carcasses and parts; tagging. Such devices and methods as may be approved by the Director of Division may be used for the temporary identification of retained carcasses, parts, or organs. In all cases the identification shall be further established by affixing "U.S. retained" tags as soon as practicable and before final inspection. These tags shall not be removed except by a division employee.

Condemned carcasses and parts to be so marked; tanking, separation. Each carcass or part which is found on final inspection to be unsound, unhealthful, unwholesome, or otherwise unfit for human food shall be conspicuously marked on the surface tissues thereof by a division employee at the time of inspection "U.S. inspected and condemned". Condemned detached parts and organs of such character that they cannot be so marked shall be placed immediately in trucks or receptacles which shall be kept plainly marked "U.S. inspected and condemned," in letter not less than 2 inches high. All condemned carcasses, parts, and organs shall remain in the custody of a division employee and shall be tanked as required in the regulations or before the close of the day on which they are condemned.

Carcasses and parts passed for cooking, marking. Carcasses and parts passed for cooking shall be marked conspicuously on the surface tissues thereof by a division employee at the time of inspection, "U.S. passed for cooking." All such carcasses and parts shall be cooked in accordance with regulations, and until so cooked shall remain in the custody of a division employee.

Disposal of parts showing localized lesions; removal of spermatic cords and pizzles. In all cases where carcasses showing localized lesions are passed for food or for cooking, the diseased parts shall be removed before the "U.S. retained" tag is taken from the carcass, and such parts shall be condemned. Spermatic cords shall be removed from hog carcasses, and pizzles from all carcasses.

Passing and marking of carcasses and parts. Carcasses and parts found to be sound, healthful, wholesome, and fit for human food shall be passed and marked as elsewhere provided.

Tuberculosis; principles for guidance in passing on carcasses affected. The following principles are declared for guidance in passing on carcasses affected with tuberculosis:

(a) No meat shall be passed for food if it contain tubercle bacilli, or it be impregnated with toxic substance of tuberculosis or associated septic infections.

(b) Meat should not be destroyed if the lesions be localized and not numerous, if there be no evidence of distribution of tubercle bacilli through the blood or by other means to the muscles or to parts that may be eaten with the muscles, and if the animal be well nourished and in good condition, since in this case there is no proof, or even reason to suspect, that the flesh is unwholesome.

(c) Evidence of generalized tuberculosis are to be sought in such distribution and number of tuberculous lesions as can be explained only upon the supposition of the entrance of tubercle bacilli in considerable number into the systemic circulation. Significant of such generalization is the presence of numerous uniformly distributed tubercles throughout both lungs, also tubercles in the spleen, kidneys, bones, joints and sexual glands, and in the lymph nodes connected with these organs and parts, or in the splenic, renal prescapular, popliteal, and inguinal nodes, when several of these organs and parts are coincidentally affected.

(d) Localized tuberculosis is tuberculosis limited to a single or several parts or organs of the body without evidence of recent invasion of numerous bacilli into the systemic circulation.

Disposition when affected with tuberculosis. The carcasses of animals affected with tuberculosis shall be disposed of as follows:

(a) The entire carcass shall be condemned if any of the following conditions occur:

(1) When it was observed before the animal was killed that it was suffering with fever.

(2) When there is a tuberculous or other cachexia.

(3) When the lesions of tuberculosis are generalized, as shown by their presence not only at the usual seats of primary infection but also in parts of the carcass or in the organs that may be reached by the bacilli of tuberculosis only when they are carried in the systemic circulation. Tuberculous lesions in any two of the following-mentioned organs are to be accepted as evidence of generalization when they occur in addition to local tuberculous lesions in the digestive or respiratory tracts, including the lymph glands connected therewith: spleen, kidney, uterus, udder, ovary, testicle, adrenal gland, and brain or spinal cord of their membranes. Numerous tubercles uniformly distributed throughout both legs also afford evidence of generalization.

(4) When the lesions of tuberculosis are found in the muscles or intermuscular tissue or bones or joints, or in the body lymph glands as a result of draining the muscles, bones, or joints.

(5) When the lesions are extensive in one or both body cavities.

(6) When the lesions are multiple, acute, and actively progressive. (Evidence of active progress consists of signs of acute inflammation about the lesions, or liquefaction necrosis, or the presence of young tubercles.)

(b) An organ or a part of a carcass shall be condemned under any of the following conditions:

(1) When it contains lesions of tuberculosis.

(2) When the lesion is localized but immediately adjacent to the flesh as in the case of tuberculosis of the parietal pleura or peritoneum. In this case not only the membrane or part affected but also the adjacent thoracic or abdominal wall is to be condemned.

(3) When it has been contaminated by tuberculous material through contact with the floor or a soiled knife or otherwise.

(4) Heads showing lesions of tuberculosis shall be condemned, except that when a head is from a carcass passed for food or for cooking and the lesions are slight, or calcified, or encapsulated, and are confined to lymph glands in which not more than two glands are involved, the head may be passed for cooking after the diseased tissues have been removed and condemned.

(5) An organ shall be condemned when the corresponding lymph gland is tuberculous.

(6) Intestines and mesenteries showing lesions of tuberculosis snall be condemned, except that when the lesions are slight and confined to the lymph glands and the carcass is passed without restriction, the intestines may be passed for use as casings and the fat passed for rendering after the corresponding lymph glands have been removed and condemned: Provided, That the fat and intestines have not been contaminated with tuberculous material.

(c) Carcasses showing lesions of tuberculosis should be passed for food when the lesions are slight, localized, and calcified or encapsulated, or are limited to a single or several

parts or organs of the body (except as noted in paragraph (a) of this section), and there is no evidence of recent invasion of tubercle bacilli into the systemic circulation. Under this paragraph, carcasses showing such lesions as the following examples may be passed, after the parts containing the lesions are removed and condemned in accordance with paragraph (b) of this section:

(1) In the cervical lymph glands and two groups of visceral lymph glands in a single body cavity, such as the cervical, bronchial, and mediastinal glands, or the cervical, hepatic, and mesenteric glands.

(2) In the cervical lymph glands and one group of visceral lymph glands and one organ in a single body cavity, such as the cervical and bronchial glands and lungs, or the cervical and hepatic glands and the liver.

(3) In two groups of visceral lymph glands and one organ in a single body cavity, such as the bronchial and mediastinal glands and the lungs, or the hepatic and mesenteric glands and the liver.

(4) In two groups of visceral lymph glands in the thoracic cavity and one group in the abdominal cavity, or in one group of visceral lymph glands in the thoracic cavity and two groups in the abdominal cavity, such as the bronchial, mediastinal, and hepatic glands, or the bronchial, hepatic, and mesenteric glands.

(5) In the cervical lymph glands and one group of visceral lymph glands in each body cavity, such as the cervical, bronchial, and hepatic glands.

(6) In the cervical lymph glands and one group of visceral lymph glands in each body cavity, together with the liver when the latter contains but few localized foci. In this class of carcasses, which will be chiefly those of hogs, the lesions of the liver are considered to be primary, as the disease is practically always of alimentary origin.

(d) Carcasses which reveal lesions more severe or more numerous than those described for carcasses to be passed (paragraph (c) of this section), but not so severe nor so numerous as the lesions described for carcasses to be condemned (paragraph (a) of this section), may be rendered into lard, rendered pork fat, or tallow, or otherwise cooked in accordance with these regulations, if the distribution of the lesions be such that all parts containing tuberculous lesions can be removed.

Anthrax, bacillary hemoglobinuria in cattle, blackleg, hemorrhagic septicemia, icterohematuria in sheep, malignant epizootic catarrh, piroplasmosis, pyemia, septicemia, unhealed vaccine lesions; carcasses affected with, to be condemned. Carcasses of animals affected with or showing lesions of any of the following named diseases or conditions shall be condemned: Anthrax, bacillary hemoglobinuria in cattle, blackleg, hemorrhagic septicemia, icterohematuria in sheep, malignant epizootic catarrh, piroplasmosis, pyemia, septicemia, unhealed vaccine lesions (vaccinia).

Brucellosis. Carcasses affected with localized lesions of brucellosis may be passed for food after the affected parts are removed and condemned.

Carcasses of animals slaughtered without ante-mortem inspection. No carcass of an animal slaughtered in the United States which has not had ante-mortem inspection by a division employee shall be brought into an official establishment, except that carcasses of cattle, sheep, swine, and goats, slaughtered by a farmer on the farm, to which the head and all viscera other than the stomach, bladder, and intestines are held by the natural attachments, may be received for inspection at official establishments where there is a veterinary meat inspector, upon the conditions prescribed. After receipt in an official establishment, every such carcass shall be given a thorough post-mortem inspection. If, on inspection of any such carcass, there be found any lesion or condition indicating that the animal was sick or diseased, the carcass shall be condemned and disposed. If on inspection the carcass be found to be free from disease and otherwise found healthful, wholesome, and fit for human food, it shall

be marked with the inspection legend.*

Tanks, rooms, and equipment used for inedible products to be separate and apart from those used for edible products. All tanks and equipment used for rendering, preparing, or storing inedible products shall be in rooms or compartments separate from those used for rendering, preparing, or storing edible products. There shall be no connection between rooms or compartments containing inedible products and those containing edible products, except that there may be one connecting doorway between the slaughtering or viscera separating department and the tank charging room of the inedible products rendering department. Pipes and chutes installed in accordance with the requirements of the Director of Division may be used to convey inedible and condemned material from edible product departments to inedible product departments.

Suppression of odors in preparing inedible product. Tanks, fertilizer driers, and other equipment used in the preparation of inedible product shall be properly equipped with condensers and other appliances which will acceptably suppress odors incident to such preparation.

Carcasses of animals condemned on ante-mortem inspection not to pass through compartments for edible products. In conveying to the inedible product tank carcasses of animals which have been condemned on ante-mortem inspection, they shall not be taken through rooms or compartments in which product is prepared, handled, or stored.

Dead-animal carcasses. (a) With the exception of dead animals which have died en route and are received with animals for slaughter at an establishment, no dead animal may be brought on the premises of an establishment unless advance permission therefor is obtained from the Director of Division.

(b) Under no circumstances shall the carcass of any animal which has died otherwise than by slaughter be brought into any room or compartment in which any product is prepared, handled or stored.

Inedible fats from outside of establishments. Inedible fats from outside the premises of an official establishment shall not be received except into the tank room provided for inedible products, and then only when their receipt into the tank room produces no insanitary condition on the premises, nor shall such fats be received in such volume as interferes with prompt disposal of inedible or condemned material produced at the establishment. When received, they shall not enter any room or compartment used for edible products.

Condemned carcasses and product; disposing of, by tanking; sealing of tanks; denaturing of product. Condemned carcasses and products at official establishments having facilities for tanking shall be disposed of by tanking as follows: (1) The lower opening of the tank shall first be sealed securely by a division employee, except when permanently connected with a blow line, then the condemned carcasses and products shall be placed in the tank in his presence, after which the upper opening shall also be sealed securely by such employee, who shall then see that the contents of the tank are subjected to sufficient heating for sufficient time to destroy effectually the contents for food purposes.

(2) The use of equipment such as crushers or hashers for pretanking preparation of condemned carcasses and product in the inedible products department has been found to give inedi-

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*Inspection legend is a mark or statement, authorized by the regulations, on a product or on the container of a product indicating that the product has been inspected and passed for food by an inspector.

ble character and appearance to the material. Accordingly, if condemned carcasses and product be so crushed or hashed, conveying systems, rendering tanks, and other equipment used in the further handling of the crushed or hashed material need not be locked or sealed during the tanking operation. If the rendering tanks or other equipment contain condemned material not so crushed or hashed, the equipment shall be sealed as prescribed in subparagraph (1) of this paragraph. If the crushed or hashed material be not rendered in the establishment where produced it shall be denatured as provided for in these regulations.

The seals of tanks shall be broken only by a division employee after the contents of the tanks have been treated. The rendered fat derived from condemned material shall be held until a division employee shall have had an opportunity to determine whether it conforms with the requirements. Samples shall be taken by division employees as often as is necessary to determine whether the rendered fat is effectually denatured.

Inedible rendered fats. Rendered animal fat derived from inedible or condemned materials and possessing the physical characteristics of color, odor, and taste of an edible product shall be denatured to effectually distinguish it from an edible product either with low grade offal during the rendering or by adding to, and mixing thoroughly with, such fat denaturing oil, number 2 fuel oil, or brucine dissolved in a mixture of alcohol and pine oil or oil of rosemary.

Disposition of condemned meat or product at official establishments having no tanking facilities. Any carcass or product condemned at an official establishment which has no facilities for tanking shall be denatured with crude carbolic acid, cresylic disinfectant, or other prescribed agent, or be destroyed by incineration, under the supervision of a division employee. When such carcass or product is not incinerated it shall be slashed freely with a knife, before the denaturing agent is applied.

Carcasses and products condemned on account of anthrax, and the materials derived therefrom at establishments which are not equipped with tanking facilities shall be disposed of by complete incineration, or by thorough denaturing with a prescribed denaturant, and then disposed of in accordance with the requirements of the particular State or municipal authorities, who shall be notified immediately by the inspector in charge.

Specimens for education, research, and other purposes; permits for, required. (a) Specimens of diseased, condemned, and inedible materials, including pig or lamb embryos and specimens of animal parasites, may be released for education or research purposes by the inspector in charge: Provided, That the party desiring such specimens makes a written application for same, stating the use to be made of them; and Provided further, That the applicant arranges with and receives permission from the official establishment to obtain the specimens. If the application be satisfactory to the inspector in charge, he shall issue a permit authorizing the removal of the specimens. Such permits shall be numbered and issued for not beyond the then current calendar year.

(b) Specimens of diseased, condemned, and inedible materials, including pig or lamb embryos and specimens of animal parasites, may be released for research and other purposes when authorized by the Director of Division: Provided, That the applicant for such specimens shall have arranged with and received permission from the official establishment to obtain them. The application to the Division for the release of such material for research purposes should include the following information: (1) The name of the organization or individual conducting the research, (2) The name of the official establishment from which the material is to be obtained, and (3) the kind and amount of material desired. In addition, the application should contain a statement that the material will be used for research purposes only and that the organization or individual conducting the research assumes full responsibility for the results of research involving this material.

(c) The collection and handling of the specimens referred to in paragraphs (a) and (b) of this section shall be at such time and place and in such a manner as not to interfere with the inspection or to cause any objectionable condition.

Livers condemned because of parasitic infestation and for other causes; conditions under which may be disposed of as fish feed. Livers condemned on account of fluke infestation may be forwarded as fish feed if they be first freely slashed, then denatured, and then frozen. The denaturing shall be accomplished by dipping the slashed livers in a hot solution composed of one part of FD & C Green #3 or Methyl Violet to 5,000 parts of water, followed by washing in fresh water until the washings are no longer colored, or by the application of finely powdered charcoal. Freezing shall be preceded by chilling the livers to a temperature not above 40° F. Livers packed in containers not more than 7 inches thick shall then be held for a period of not less than 10 days at a temperature not higher than 15° F. or for a period of not less than 5 days at a temperature not higher than 10° F. Livers packed in containers over 7 inches but less than 27 inches thick shall be held not less than 20 days at a temperature not higher than 15° F., or for not less than 10 days at a temperature not higher than 10° F. In lieu of freezing, the livers may be thoroughly cooked and then slashed and denatured in the manner indicated above. It is essential that the livers be sufficiently denatured through discoloration by the dye or charcoal to preclude their use as human food. Freezing may be accomplished in the regular freezer in a properly separated compartment or receptacle held under division lock.

Livers condemned on account of hydatids or fringed tapeworms may not be forwarded as fish unless thoroughly cooked, slashed, and denatured.

Livers condemned on account of parasites other than flukes, hydatids, or fringed tapeworms may be forwarded as fish feed without refrigeration or cooking after slashing and denaturing.

Livers condemned for telangiectasis, angioma, "sawdust" condition, cirrhosis, or other non-malignant change, benign abscesses, or contamination, when these conditions are not associated with infectious diseases in the carcasses, may be forwarded as fish feed without refrigeration or cooking: Provided, All tissue affected with abscesses be removed and destroyed within the establishment: And provided further, That all livers be slashed and denatured.

Livers specified in the foregoing paragraphs shall be placed in containers plainly marked "fish feed - inedible," and when shipped in interstate commerce shall be certified as required.

Carcasses and parts passed for cooking, rendering into lard, rendered pork fat, or tallow. Carcasses and parts passed for cooking may be rendered into lard or rendered pork fat or rendered into tallow: Provided, Such rendering be done in the following manner:

(1) When closed rendering equipment is used, the lower opening, except when permanently connected with a blow line, shall first be sealed securely by a division employee, then the carcasses or parts shall be placed in such equipment in his presence, after which the upper opening will be securely sealed by such employee. When the product passed for cooking in the tank does not consist of a carcass of whole primal part, the requirements for sealing shall be at the discretion of the inspector in charge. Such carcasses and parts shall be cooked for a time sufficient to render them effectually into lard, rendered pork fat, or tallow: Provided, all parts of the product be heated to a temperature not lower than 170° F. for a period of not less than 30 minutes.

(2) Establishments not equipped with closed rendering equipment for rendering carcasses and parts passed for cooking into lard, rendered pork fat, and tallow may render such carcasses or parts in open kettles under the direct supervision of a division employee. Such rendering shall be done during regular hours of work and in compliance with the requirements as to temperature and time specified in the above paragraph.

Carcasses and parts passed for cooking not rendered into lard, rendered pork fat, or tallow; utilization of, for food purposes after cooking. Carcasses and parts passed for cooking, except as specified may be used for the preparation of such products as canned meat, sausage, cooked or boiled meat, meat loaves, and similar products: Provided, All parts of such carcasses and parts which are so used be heated to a temperature not lower than 170° F. for a period of not less than 30 minutes, either before being used in or during the preparation of the

finished product.

When product passed for cooking is used as an ingredient of a meat food product at least 50 percent of the meat and meat byproduct ingredient shall consist of product passed for cooking. This requirement shall not apply when the product passed for cooking has been previously cooked as specified above before being used as an ingredient of a meat food product.

Disposal of product passed for cooking if not handled according to this part. Product passed for cooking if not handled and processed in the above-stated manner shall be disposed of in accordance with provisions for condemned carcasses.

Approval of abbreviations of marks of inspection. The Director of the division may approve and authorize the use of abbreviations of marks of inspection. Such abbreviations shall have the same force and effect as the respective marks for which they are authorized abbreviations.

Preparation of marking devices bearing inspection legend without advance approval prohibited; exception. Except for the purposes of submitting a sample or samples of the same to the Director of Division for approval, no person shall procure, make or prepare, or cause to be procured, made, or prepared, labels, brands, or other marking devices bearing the inspection legend or any abbreviations, copy or representation thereof, for use on any product without the written authority therefor of the Director of the Division. However, when any sample label, brand, or other marking device is approved by the Director of Division, new supplies of such labels and new brands and other marking devices of a character exactly similar to such approved sample may be procured, made, or prepared, for use in accordance with the regulations, without further approval by the Director of Division.

Use of inspection legend prohibited except under supervision of division employee. (a) No person shall affix or place, or cause to be affixed or placed, the inspection legend, or any abbreviation, copy, or representation thereof, to or on any product or container thereof, except under the supervision of a division employee.

(b) No person shall fill, or cause to be filled, in whole or in part, with any product, any container bearing or intended to bear, the inspection legend, or any abbreviation, copy, or representation thereof, except under the supervision of a division employee.

Brands and marking devices to be approved by Director of Division; control of brands, etc. Official establishment shall furnish such ink brands, burning brands, and like devices for marking product as the Director of Division may require. The mark of inspection on such a device shall be in the circular form as a facsimile (Fig. 1) of one of the official brands, using the size best suited for the purpose intended. In advance of manufacture, complete and accurate descriptions and designs of the same shall be submitted to and approved by the Director of Division. Every such brand and device which bears the inspection legend shall be delivered into the custody of the inspector in charge of the establishment, and shall be used only under the supervision of a division employee. When not in use for marking inspected and passed product, all such brands and devices bearing the inspection legend shall be kept locked in properly equipped lockers or compartments, the keys of which shall not leave the possession of a division employee.

Fig. 1 Meat Inspection Label

Articles not to be removed from establishments unless marked in accordance with regulations. No person shall remove or cause to be removed from an official establishment any article which the regulations in this subchapter require to be marked in any way unless the same be clearly and legibly marked in compliance with the regulations.

Marks of inspection to be carefully applied. All marks of inspection shall be carefully applied and securely affixed.

Branding ink to be furnished by establishment; approval by division, color. Official

establishments shall furnish all ink for marking product. Such ink must be made with harmless ingredients that are approved for the purpose by the division. Samples of ink shall be submitted to the meat inspection laboratory from time to time as may be deemed necessary to the inspector in charge.

(1) Only purple ink approved for the purpose shall be used to apply ink brands bearing the marks of inspection to carcasses and fresh meat cuts derived therefrom.

(2) Ink brands bearing the marks of inspection used for purposes other than in subparagraph (1) of this paragraph may be applied with branding ink of any color and composition that will assure ready legibility and permanence of marking, except as provided in (3) of this paragraph. The color of the ink shall provide acceptable contrast with the color of the product to which it is applied.

(3) Product shall not be marked with green ink except that, if desired by the establishment, such ink may be used for holiday markings and designs.

Control and use of brands and marking devices furnished by division. All brands and devices furnished by the division for marking articles with the inspection legend, including self-locking seals, shall be used only under the supervision of a division employee, and, when not in use for marking, shall be kept locked in properly equipped lockers or compartments, the keys of which shall not leave the possession of a division employee.

Brands and marking devices not to be false or misleading; style and size of lettering. No brand or device shall be false or misleading. The letters and figures thereon shall be of such style and type as will make a clear and legible impression.

Carcasses, primal parts, and products; marking with inspection legend. (a) Each carcass which has been inspected and passed in an official establishment shall be marked at the time of inspection with the inspection legend and with the number of the establishment.

(b) Except as provided otherwise, each carcass, each primal part of a carcass, the beef cod fat, and beef kidney fat, and each liver, beef tongue, and beef heart which has been inspected and passed shall be marked with the inspection legend and the number of the establishment before it leaves the establishment in which it is first inspected and passed, and each inspected and passed product susceptible of being marked shall be marked with the inspection legend and number of the establishment where it was last processed: Provided, That skinned bacon intended for slicing need not be so marked if packed in properly marked containers. Additional marks of inspection may be applied as desired to meet local conditions.

(c) Beef livers shall be marked with the inspection legend and the establishment number on the convex surface of the thickest portion of the organ.

Moving and handling of primal parts from one establishment to another. Primal parts of carcasses which have been inspected and passed but do not bear the inspection legend may be transported from one official establishment to another official establishment, for further processing, in a car, truck, or other closed container, if the car, truck or container be sealed with a division seal bearing the inspection legend in compliance with the regulations.

Handling of products too small to be marked with brand. Any product of such character or so small that it cannot be marked with a brand, and which has been inspected and passed but does not bear the inspection legend, may be removed from an official establishment for local or interstate transportation in closed containers bearing the inspection legend and such other marks as are required by the regulations or in open containers bearing the inspection legend applied by means of a domestic meat label or trade label: Provided, That upon removal from such closed or open containers the product may not be further transported in interstate or foreign commerce unless reinspected by a division employee and packed under his supervision in a container or containers bearing the inspection legend and such other marks as are required by the regulations: And provided further, That unmarked product shall not be brought into an official establishment in an open container, except that which is returned to the establishment, and this must be held separate from other product pending removal from the

establishment for disposal in intrastate trade only.

Marking of meat food products in casings. (a) Inspected and passed sausage and other products in casings, of the ordinary "ring" variety or larger, shall be marked with the inspection legend and the number of the establishment. Inspected and passed sausage and other products in casings, of the smaller varieties, shall bear one or more inspection marks to each chain or two or more of such marks to each bunch, except in cases where smaller varieties of sausage and products leave establishments completely enclosed in properly labeled cartons or wrappers, having a capacity of 10 pounds or less and containing a single kind of product: Provided, That the mark of inspection need appear only twice throughout the contents of containers, exceeding a capacity of 10 pounds, of sausages of the smaller varieties shipped to another official establishment for further processing, or to a governmental agency. When such products are shipped to another official establishment for further processing, the inspector in charge at the point of origin shall identify the shipment to the inspector in charge at destination.

(b) Meat food products in casings, other than sausage, which possess the characteristics of or resemble sausage, shall bear on each link or piece the word "imitation" prominently displayed: Provided, That such products in casings as coppa, capocollo, lachschinken, bacon, pork loins, pork shoulder butts, and similar cuts of meat which are prepared without added substances other than curing materials or condiments, and meat rolls, bockwurst, and similar products in casings which do not contain cereal or vegetables, and head-cheese, souse, sulze, scrapple, blood pudding, and liver pudding in casings need not be so marked; other products in casings such as loaves, chili con carne, and meat and cheese products when prepared with sufficient cheese to give definite characteristics to the finished products, may bear on each link or piece the true name of the product in lieu of the word "imitation"; and imitation sausage packed in properly labeled containers having a capacity of 1 pound or less and of a kind usually sold at retail intact, need not bear the word "imitation" on each link or piece if no other marking or labeling be applied to the product.

(c) When cereal, vegetable starch, starchy vegetable flour, soya flour, dried milk is added to sausage within the limits prescribed under these regulations, the product shall be marked with the name of each such added ingredients, as for example, "cereal added," "potato flour added," "cereal and potato flour added," "soya flour added," "nonfat dry milk added," "cereal and nonfat dry milk added," etc., as the case may be. On sausage of the smaller varieties, the marking prescribed in this paragraph may be limited to links bearing the inspection legend.

(d) (1) When product is placed in casing to which artificial coloring is applied, as permitted herein, the article shall be legibly and conspicuously marked by stamping or printing on the casing or securely affixing to the article the words "artificially colored".

(2) If the casing be removed from product at an official establishment and there be evidence of artificial coloring on the surface of the product, the article from which the casing has been removed shall be marked by stamping directly thereon or by securely affixing thereto the printed words "artificially colored".

(3) The casing containing product need not be marked to show that it is colored if it be colored prior to its use as a covering for the product, and the coloring be of a kind and so applied as not to be transferable to the products and not to be misleading or deceptive with respect to color, quality, or kind of product enclosed in the casing.

(4) In the case of sausage of the smaller varieties the marking prescribed in this paragraph may be limited to links bearing the inspection legend.

(e) When approved antioxidants are added to unsmoked dried sausage in casings the product shall be legibly and conspicuously marked in an approved manner to show their presence and the purpose for which they are added, for example, with the statement "oxygen interceptor added to improve stability".

(f) A cloth bag, artificial casing, or similar container of sausage or other product of a size larger than that customarily sold at retail intact shall be printed with the mark of inspection and any other marks required under paragraphs (b) through (e), near each end of the product, so as to be clearly visible to the consumer: Provided, That such articles which are printed with a label in conformity with these regulations need not, in addition, show markings other than the mark of inspection near each end.

(g) The markings indicated in the above paragraph shall be branded near each end of sausage or similar product prepared in animal casings when the article is of a size larger than that customarily sold at retail intact.

(h) All markings may be omitted from sausage and other meat foods products in casings when these articles are to be processed in sealed container.

Marking product with the list of ingredients. A product fabricated from two or more ingredients shall bear a list of the ingredients, giving the common or usual names of the ingredients, arranged in the order of their predominance, except that spices may be designated as "spices" or "flavorings," and flavorings (including essential oils, oleoresins, and other spice extractives) may be designed as "flavorings" without naming each. The list of ingredients shall be applied legibly and securely to the product by means approved by the Director of Division, such as stamping, printing, or the use of paper bands, tags, or tied-in paper or fabric flaps on stuffed sausage, or tissue strips on loaf-like articles: Provided, That product for which a definition and standard of identity has been prescribed which conforms to such definition and standard, and which bears the name specified in the definition and standard, together with such declaration of optional ingredients and other labeling features as are required by the applicable definition and standard, need not bear a list of ingredients: Provided further, That bockworst and sausages of the smaller varieties, such as frankfurters and pork sausage, shall bear the list of ingredients at least once on each 2 pounds of product: Provided further, That when such product is distributed from an official establishment in an immediate or true container of a type and size customarily sold at retail intact, the list of ingredients on the label of the package shall be sufficient. And provided further, That when sausages of the smaller varieties be shipped to another official establishment for further processing, or to a governmental agency, the list of ingredients used appear only twice throughout the contents of containers and when so shipped may be omitted from the contents of containers of 10-pound size or less. When such products are shipped to another official establishment for further processing, the inspector in charge at the point of origin shall identify the shipment to the inspector in charge at destination by means of Form MI 408-1.

Marking of shipping containers; domestic meat label. (a) Except as provided, when any inspected and passed product for domestic commerce is moved from an official establishment, the shipping container shall bear an approved mark of inspection or an approved domestic meat label, whichever is appropriate. The domestic meat label shall be printed with black ink on white paper of good quality, shall be 2 3/4 by 4 inches in size and shall be in form and substance as illustrated (Fig. 2), except that the name and address of the establishment, or the name only, may also be printed on the label, at the bottom thereof.

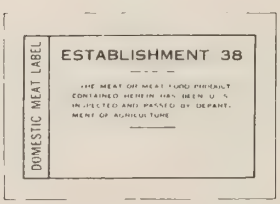

Fig. 2 Domestic Meat Label

The domestic meat label shall be printed with black ink on white paper of good quality, except that in the case of fiberboard shipping containers it may be printed directly on such containers in black ink on any color background, except green, which offers sufficient contrast so that it is prominently and informatively displayed.

(b) When any product prepared in an official establishment for domestic commerce has been inspected and passed and is enclosed in a cloth wrapping, such wrapping may bear, in lieu of the domestic meat label, the inspection legend and establishment number applied by the approved 2 1/2-inch rubber brand: Provided, The domestic meat label or rubber brand may

be omitted in those cases in which the inspection legend and establishment number on the articles themselves are clearly legible through the wrapping or the wrapping is labeled in accordance with this subchapter: Provided further, That plain unprinted wrappings such as stockinettes, cheese cloth, paper and crinkled paper bags for properly marked fresh meat including carcasses, and primal parts thereof, which are used solely to protect the product against soiling or excessive drying during transportation or storage need not bear the marks of inspection.

(c) The shipping or outside containers of products for export shall be marked in compliance with this subchapter.

Horse carcasses, meat and meat food products thereof; marking and labelling. All horse carcasses, parts of carcasses, meat and meat food products thereof shall be conspicuously labelled, marked, branded, or tagged "horse meat" or "horse-meat product". See Fig. 3. Only green ink shall be used in branding horse meat and horse-meat product with the mark of inspection.

Fig. 3 Horse Meat Inspection Label

Horse meat or meat food products thereof: domestic meat labels. The domestic meat labels for horse meat or meat food products thereof shall be printed with black ink on light green paper of good quality, shall be 2 3/4 by 4 inches in size and shall be in form and substance as illustrated (Fig. 4), except that the name and address of the establishment, or the name only, may also be printed on the label at the bottom thereof.

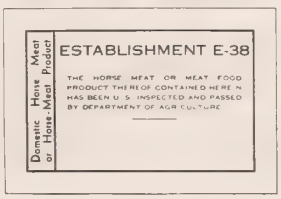
Domestic Horse Meat or Horse-Meat Product
ESTABLISHMENT E-38
THE HORSE MEAT OR MEAT FOOD PRODUCT THEREOF CONTAINED HERE IN HAS BEEN U S INSPECTED AND PASSED BY DEPARTMENT OF AGRICULTURE

Fig. 4 Domestic Horse Meat Label

Tank cars and tank trucks of edible product. Each tank car and each tank truck carrying inspected and passed product from an official establishment shall bear a label containing the true name of the product, the inspection legend, the establishment number, and the words "date of loading," followed by a suitable space for the insertion of the date. The label shall be located conspicuously and shall be printed on material of such character and so affixed as to preclude detachment or effacement upon exposure to the weather. Before the car or truck is removed from the place where it is unloaded, the carrier shall remove or obliterate such label.

Transferring inspected and passed product for export. When inspected and passed products for export are transferred from tank cars to other containers on boats, such transfer shall be under division supervision, and the containers on the boats shall be labeled in the same manner as required in the above paragraph.

Denaturing of inedible grease, etc.; marking "inedible". (a) Inedible grease, inedible tallow, or other inedible animal fat, or mixture containing such fat, having the physical characteristics of an edible product shall be denatured or otherwise destroyed for food purposes. Containers of such inedible grease, inedible tallow, or other inedible fat shall be marked conspicuously with the word "inedible". Such containers as tierces, barrels, and half barrels shall have both ends painted white with durable paint, if necessary, to provide a contrasting background and the word "inedible" marked thereon in letters not less than 2 inches high.

(b) Inspected rendered animal fat which for any reason it is desired to classify as inedible may be shipped interstate if handled as provided in paragraph (a) of this section for inedible fat having the physical characteristics of an edible product.

(c) Uninspected non-exempt rendered animal fat, or mixtures containing such fat, having the physical characteristics of an edible product may be shipped interstate if handled as provided in paragraph (a) of this section for inedible fat having the physical characteristics

of an edible product.

Labelling* required: supervision by division employee. (a) When, in an official establishment, any inspected and passed product is placed or packed in any can, pot, tin, canvas, or other receptacle or covering constituting an immediate or true container, there shall be affixed to such container or covering a label as hereinafter described: Provided, That plain wrappings for fresh meat, such as dressed carcasses and primal parts thereof, which are used solely to protect the product against soiling or excessive drying during transportation or storage need not bear a label: Provided further, That uncolored transparent coverings, such as cellophane, which bear no printed or graphic matter and which enclose any unpackaged or packaged product bearing all required markings need not bear a label if the required markings be clearly legible through such coverings: Provided further, That animal and transparent artificial casings bearing no marks or printed features other than those required need not bear additional labeling: And provided further, That stockinettes used as "operative devices," such as those applied to cured meats in preparation for smoking, need not bear labels whether or not such stockinettes are removed following completion of the operations for which they are applied.

(b) Folders and similar coverings made of paper or like material, which do not completely enclose the product and which bear any printed word or statement, shall bear all features required on a label for an immediate or true container.

(c) No container or covering which bears or is to bear a label shall be filled, in whole or in part, except with product which has been inspected and passed in compliance with this chapter, which is sound, healthful, wholesome, and fit for human food, and which is strictly in accordance with the statements on the label. No such container or covering shall be filled, in whole or in part, and no label shall be affixed thereto, except under the supervision of a Division employee.

Labels: What to contain, when and how used. (a) Labels shall include any printing, lithographing, embossing, or other marking on labels, stickers, seals, wrappers, or receptacles.

(b) Labels shall contain, prominently and informatively displayed, (1) the true name of the product; (2) the word "ingredients" followed by a list of the ingredients when the product is fabricated from two or more ingredients, except in the case of products for which definitions and standards of identity have been prescribed; (3) the name and place of business of the manufacturer, packer, or person for whom the product is prepared; (4) an accurate statement of the quantity of contents; and (5) an inspection legend and the number of the establishment in the form shown herewith, on that portion of the label featuring the name of the product, or, when there are two or more panels, then on the principal display panels. However, in lieu of showing the inspection legend and the establishment number in such form, in the case of large size fiberboard immediate containers, a domestic meat label may be printed directly on such containers in size, form and substance as provided in this chapter for use on fiberboard shipping containers. The name and place of business of the manufacturer, packer, or person for whom the product was prepared and the statement of quantity of contents may be omitted from labels for product not required to be labeled: Provided further, That the establishment number may be omitted from the labels on cartons used as outer containers of edible fats, such as lard and oleomargarine, when such articles are enclosed in wrappers which bear an inspection

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*Note: Approvals prior to July 1, 1950, of labeling material for imported meats, meat byproducts, and meat food products were canceled effective April 1, 1957 (22 F.R. 738, Feb. 6, 1957.) Any person who proposes to use labeling material, for meats, meat byproducts, or meat food products to be imported into the United States on or after April 1, 1957, which was approved prior to July 1, 1950, and has not since been reapproved, must submit such labeling material to the Director of the Meat Inspection Division for approval under the regulations currently in effect.

legend (Fig. 5) and establishment number; and from a label lithographed directly on a can bearing the embossed or lithographed establishment number: And provided further, That a metal container on which an inspection legend is embossed or lithographed may, with the approval of the Director of Division, bear an inspection legend of different design and in abbreviated form.

(1) The name of a product shall be the common name, if any, and one which clearly and completely identifies the article. Product which has been prepared by salting, smoking, drying, cooking, chopping, and the like shall be so described on the label unless the name on the article implies, or the manner of packaging shows, that the product was subjected to such procedure or procedures. The unqualified terms "meat," "meat byproduct," "meat food product," and terms common to the meat industry, but not to consumer such as "picnic," "butt," "cala," "square," "loaf," "spread," "delight," "roll," "plate," "luncheon," and "daisy," shall not be used as names of articles unless accompanied with terms descriptive of the product or with a list of ingredients.

Fig. 5 U.S. Inspected and Passed Label

(2) The list of ingredients shall appear as part of or in addition to the true name of the product and shall show the common or usual names of the ingredients arranged in the order of their predominance, except that spices may be designated as "spices" or "flavorings," and flavorings (including essential oils, oleoresins, and other spice extractives) may be designated as "flavorings" without naming each. The name of an ingredient shall not be a collective name but shall be a specific name, as for example, "beef," "pork": Provided, That when a product is coated with pork fat, gelatin, or other approved substance and a specific declaration of such coating appears in connection with the name of product, the ingredient statement need not make reference to the ingredients of such coating: And provided further, That when the label bears the designation "compound" or "shortening" the term "animal and vegetable fats" or "vegetable and animal fats" may be employed to designate the ingredients of mixtures of such edible fats. "Animal fats" as used herein means inspected and passed fat derived from cattle, sheep, swine, or goats.

(3) The name of the manufacturer or packer may appear without qualification on the label or the container of product. When the name of the manufacturer or packer is not that under which inspection is granted at the establishment but is the name of a tenant operating in the establishment, full information identifying the tenant and the scope of his operations shall be furnished to the Director of Division. When product is not prepared by the person whose name appears on the label, the name shall be qualified by a phrase which reveals the connection such person has with such product, as for example, "Prepared for.....".

(c) Stencils, box dies, inserts, tags, and like devices shall not bear an inspection legend or any abbreviation or representation thereof: Provided, That with the approval of the Director of Division, box dies including the inspection legend and establishment number may be used in marking wooden boxes of light material having a maximum capacity of five pounds, fiber board containers, and wood wire-bound boxes and crates with at least 90 percent of the total wood surfaces being veneer wood not over one sixth of an inch thick and of such quality that matter imprinted on it is legible.

(d) The establishment number shall be either embossed or lithographed on all sealed metal containers of inspected and passed product filled in an official establishment, except that such containers which bear labels lithographed directly on the can and in which the establishment number is incorporated need not have the establishment number embossed or lithographed thereon. Labels shall not be affixed to containers so as to obscure the embossed or lithographed establishment number.

(e) When any product is placed in a carton or in a wrapper of paper or cloth or in such other labeled container or covering as the Director of Division may approve, an inspection legend and the establishment number may be embodied on a sticker to be securely and prominently affixed, along with the name of product, at a place on the label reserved and designated

for the purpose. In case there are two or more display panels featuring the name of product, the inspection sticker shall be affixed to the principal panel or panels. The inspection sticker shall not be used without the approval of the Director of the Division and shall be affixed to the label under the supervision of a division employee.

(f) Meat and meat food products packaged in consumer size impervious film containers which are usually displayed in self-service refrigerated counters shall have a statement such as "Keep Refrigerated" prominently displayed on the principal display panel of the label.

Labels to conform with definitions and standards of identity. When inspected and passed products are labeled with the names of, or are represented as, articles for which definitions and standards of identity have been prescribed, the labels shall conform to such definitions and standards.

Labels to be approved by Director of Division. (a) Except as provided in paragraph (d) of this section no label shall be used on any product until it has been approved in its final form by the Director of Division. For the convenience of the establishment sketches or proofs of new labels may be submitted in triplicate through the inspector in charge to the Division for approval and the preparation of finished labels deferred until such approval is obtained. All finished labels shall be submitted in quadruplicate through the inspector in charge to the Division for approval.

(b) In case of lithographed labels, paper take-offs in lieu of sections of the metal containers shall be submitted for approval. Such paper take-offs shall not be in the form of a negative but shall be a complete reproduction of the label as it will appear on the package, including any color scheme involved. In case of fiber containers, printed layers, such as the kraft paper sheet, shall be submitted for approval in lieu of the complete container.

(c) Inserts, tags, liners, posters, and like devices containing printed or graphic matter and for use on, or to be placed within, containers and coverings of product shall be submitted for approval in the same manner as provided for labels in paragraph (a) of this section, except that inspectors in charge may permit use of such devices which contain no reference to product and bear no misleading feature.

(d) Stencils, labels, box dies, and brands may be used on shipping containers and on such immediate containers as tierces, barrels, drums, boxes, crates, and large size fiber board containers provided the markings are applicable to the product, are not false or deceptive, and are used with the approval of the inspector in charge. The inspection legend for use in combination with such markings shall be approved by the Director of Division whether the legend is applied in the form illustrated herein or by means of a domestic meat label.

Inspector in charge to permit certain modifications of approved labels. The inspector in charge may permit the use of approved labels or other markings modified as follows provided the labeling as modified is so used as not to be false or deceptive:

(a) When all features of the label or marking are proportionately enlarged and the color scheme remains the same.

(b) When changes are made in the figures denoting the quantity of contents or when there is substitution of such abbreviations as "lb." for "pound," "oz." for "ounce," or the word "pound" or "ounce" is substituted for the abbreviation.

(c) When a master or stock label is approved from which the name and address of the distributor are omitted and such name and address are applied before being used. The words "prepared for" or similar statement must be shown together with the blank space reserved for the insertion of the name and address when such labels are offered for approval.

(d) When, during Christmas and other holiday seasons, wrappers or other covers bearing floral or foliage designs or illustrations of rabbits, chicks, fireworks, or other emblematic holiday designs are used with approved labels or markings. The use of such designs will not make necessary the application of labeling not otherwise required.

(e) When there is a slight change in arrangement of directions pertaining to the opening of cans or the serving of the product.

(f) When there is a change in the order or predominance of the ingredients on the label corresponding with a change in the formula used to prepare the product: Provided, That no new ingredients are added and none are omitted. Nothing in this paragraph shall be construed to modify any requirement of these regulations which provides either minimum or maximum limits for the use of certain ingredients.

Approved labels to be used only on products to which they are applicable. Labels shall be used only on products for which they are approved. They shall not be applied to any product the container or covering of which bears any statement that is false or misleading or is so made, formed, or filled as to be deceptive or misleading.

Product for foreign commerce; printing labels in foreign language permissible. Labels to be affixed to packages of product for foreign commerce may be printed in a foreign language and may show the statement of the quantity of contents in accordance with the usage of the country to which exported. Deviations from the form of labeling required under this subchapter may be approved by the Director of Division: Provided, (a) That the proposed labeling accords to the specifications of the foreign purchaser, (b) That it be not in conflict with the laws of the country to which it is intended for export, and (c) That the outside of the shipping package be labeled to show that it is intended for export; but if such product be sold or offered for sale in domestic commerce all the requirements of this chapter apply. The inspection legend and the establishment number shall in all cases appear in English, but, in addition, may appear literally translated in a foreign language.

False or deceptive labeling and practices. (a) No product, and no container thereof, shall be labeled with any false or deceptive name, but established trade names which are usual to such articles and are not false or deceptive and which have been approved by the Director of Division may be used.

(b) A label for product which is in imitation of another food shall bear the word "imitation" immediately preceding the name of the food imitated and in the same size and style of lettering as in that name and immediately thereafter the word "ingredients" and the names of the ingredients arranged in the order of their predominance.

(c) No statement, word, picture, design, or device, which conveys any false impression or gives any false indication of origin or quality shall appear on any label. For example:

(1) Terms having geographical significance with reference to a locality other than that in which the product is prepared may appear on the label only when qualified by the word "style," "type," or "brand," as the case may be, in the same size and style of lettering as in the geographical term and accompanied with a prominent qualifying statement identifying the country, state, territory, or locality in which the product is prepared, using terms appropriate to effect the qualification. When the word "style" or "type" is used, there must be a recognized style or type of product identified with and peculiar to the locality represented by the geographical term and the product must possess the characteristics of such style or type, and the word "brand" shall not be used in such a way as to be false or deceptive: Provided, That a geographical term which has come into general usage as a trade name and which has been approved by the Director of Division as being a generic term may be used without the qualifications provided for in this paragraph. The terms "frankfurter," "vienna," "bologna," "lebanon bologna," "braunschweiger," "thuringer," "genoa," "leona," "berliner," "holstein," "goteborg," "milan," "polish," and their modifications as applied to sausages, the terms "brunswick," and "irish" as applied to stews, and the term "boston" as applied to pork shoulder butts, need not be accompanied with the word "style," "type," or "brand" or a statement identifying the locality in which the product is prepared.

(2) Such terms as "farm," "country," and the like shall not be used on labels in connection with products unless such products be actually prepared on the farm or in the country: Provided, That if the product be prepared in the same way as on the farm or in the country these terms, if qualified by the word "style" in the same size and style of lettering, may be used: Provided further, That the term "farm" may be used as part of a brand designation when qualified by the word "brand" in the same size and style of lettering, and followed with a statement identifying the locality in which the product is prepared. Sausage containing cereal shall not be labeled "farm style" or "country style," and lard not rendered in an open kettle shall not be designated as "farm style" or "country style".

(3) The requirement that the label shall contain the name and place of business of the manufacturer, packer, or distributor shall not be considered to relieve any establishment from the requirement that its label shall not be misleading in any particular.

(4) The term "spring lamb" or "genuine spring lamb" is applicable only to carcasses of new-crop lambs slaughtered during the period beginning in March and terminating not beyond the close of the week containing the first Monday in October.

(5) Coverings shall not be of such color, design, or kind as to be misleading or deceptive with respect to color, quality, or kind of product to which they are applied. For example, transparent or semitransparent coverings for such articles as sliced bacon or pork sausage shall not bear lines or other designs of red or other color which gave a false impression of leanness of the product.

(6) The word "fresh" shall not be used on labels to designate product which contains any sodium nitrate, sodium nitrite, potassium nitrate, or portassium nitrite, or which has been salted for preservation.

(7) The words, "spice," "spices," and "spiced," without qualification, shall not be used unless they refer to genuine natural spices.

(8) As used on labels of meat or product, the term "gelatin" shall mean (1) the jelly prepared in official establishments by cooking pork skins, tendons, or connective tissue from inspected and passed product, and (2) dry commercial gelatin or the jelly resulting from its use.

(9) Product (other than canned product) labeled with the term "loaf" as its name or part of its name shall be prepared in loaf form with sufficient stability to withstand handling before being placed in a wrapper, casing, or the like.

(10) The term "baked" shall apply only to the product which has been cooked by the direct action of dry heat and for a sufficient time to permit the product to assume the characteristics of a baked article, such as the formation of a brown crust on the surface, rendering out of surface fat, and the caramelization of the sugar if applied. Baked loaves shall be heated to a temperature of at least 160° F. and baked pork cuts shall be heated to an internal temperature of at least 170° F.

(11) When product such as loaves is browned by dipping in hot edible oil or by a flame, its label shall state such fact, the words "Browned in Hot Cottonseed Oil" or "Browned by a Flame," as the case may be, appearing as part of the name of product.

(12) The term "meat" and the names of particular kinds of meat, such as beef, veal, mutton, lamb, and pork, shall not be used in such manner as to be misleading or deceptive.

(13) The word "ham," without any prefix indicating the species of animal from which derived, shall be used on labels only in connection with pork hams. Ham shanks as such or ham shank meat as such or the trimmings accruing in the trimming and shaping of hams shall not be labeled "ham" or "ham meat" without qualification. When used in connection with a chopped product the term "ham" or "ham meat" shall not include the skin.

(14) The terms "shankless" and "hockless" shall apply only to hams and pork shoulders from which the shank or hock has been completely removed, thus eliminating the entire tibia and fibula, or radius and ulna, respectively, together with the overlying muscle, skin, and other tissue.

(15) Such terms as "meat extract" or "extract of beef" without qualification shall not be used on labels in connection with products prepared from organs or parts of the carcass other than fresh meat. Extracts prepared from any parts of the carcass other than fresh meat shall not be labeled "meat extract" but may be properly labeled with the true name of the parts from which prepared. In the case of extract in fluid form, the word "fluid" shall also

appear on the label, as, for example, "fluid extract of beef". Meat extract shall contain not more than 25 percent of moisture. Fluid extract of meat shall contain not more than 50 percent of moisture.

(16) When cereal, vegetable starch, starchy vegetable flour, soya flour, dried milk, or dried skim milk is added to sausage within the limits prescribed, there shall appear on the label in a prominent manner, contiguous to the name of the product, the name of each such added ingredient, as, for example, "cereal added," "with cereal," "potato flour added," "cereal and potato flour added," "soya flour added," "dried skim milk added," "cereal and dried skim milk added," as the case may be.

(17) When any product is enclosed in a container along with a packing substance such as brine, vinegar, or agar jelly, a declaration of the packing substance shall be printed prominently on the label in connection with the name of product, as, for example, "frankfurts packed in brine," "lamb tongue packed in vinegar," or "beef tongue packed in agar jelly," as the case may be. The statement of quantity of contents shall represent the weight of the drained product when removed from the container to the exclusion of the packing substance. The packing substance shall not be used in such a manner as will result in the container being so filled as to be misleading.

(18) The term "lard" is applicable only to the fat rendered from fresh, clean, sound, fatty tissues from hogs in good health at the time of slaughter, with or without lard stearin or hydrogenated lard. The tissues do not include bones, detached skin, head skin, ears, tails, organs, windpipes, large blood vessels, scrap fat, skimmings, settlings, pressings, and the like, and are reasonably free from muscle tissue and blood.

(19) The term "leaf lard" is applicable only to lard prepared from fresh leaf fat.

(20) The term "rendered pork fat" is applicable to the fat other than lard, rendered from clean, sound carcasses, parts of carcasses, or edible organs from hogs in good health at the time of slaughter, except that stomachs, bones from the head, and bones from cured or cooked pork are not included. The tissues rendered are usually fresh, but may be cured, cooked, or otherwise prepared and may contain some meat food products. Rendered pork fat may be hardened by the use of lard stearin and/or hydrogenated lard and/or rendered pork fat stearin and/or hydrogenated rendered pork fat.

(21) When lard or hardened lard is mixed with rendered pork fat or hardened rendered pork fat, the mixture shall be designated as "rendered pork fat" or "hardened rendered pork fat," as the case may be.

(22) Oil, stearin, or stock obtained from beef or mutton fats rendered at a temperature above 170° F. shall not be designated as "oleo oil," "oleo stearin," or "oleo stock," respectively.

(23) When not more than 20 percent of beef fat, mutton fat, oleo stearin, vegetable stearin, or hardened vegetable fat is mixed with lard or with rendered pork fat, there shall appear on the label, contiguous to and in the same size and style of lettering as the name of product, the words "beef fat added," "mutton fat added," "oleo stearin added," or "hardened vegetable fat added," as the case may be.

(24) The designation "vegetable fat" is applicable to vegetable oil, vegetable stearin, or a combination of such oil and stearin, whereas the designations "vegetable oil" and "vegetable stearin" shall be applicable only to the oil and the stearin, respectively.

(25) No rendered edible animal fat or mixture of fat containing rendered edible animal fat shall contain added water, except that puff-pastry shortening may contain not more than 10 percent of water, and oleomargarine may contain water within the limits prescribed.

(26) Containers of edible rendered animal fats and mixtures of edible fats containing animal fats shall, before or immediately after filling, be legibly marked with the true name of

the product.

(27) Product labeled "Chili Con Carne" shall contain not less than 40 percent of meat computed on the weight of the fresh meat. Head meat, cheek meat, and heart meat exclusive of the heart cap may be used to the extent of 25 percent of the meat ingredient under specific declaration on the label. The mixture may contain not more than 8 percent, individually or collectively, of cereal, vegetable starch, starchy vegetable flour, soya flour, dried milk or dried skim milk.

(28) Product labeled "chili con carne with beans" shall contain not less than 25 percent of meat computed on the weight of fresh meat. Head meat, cheek meat, and heart meat exclusive of the heart cap may be used to the extent of 25 percent of the meat ingredient under specific declaration on the label.

(29) Product labeled "hash" shall contain not less than 35 percent of meat computed on the weight of the cooked and trimmed meat. The weight of the cooked meat used in this calculation shall not exceed 70 percent of the uncooked weight of the fresh meat.

(30) Products labeled as meat stews, for example, "beef stew," "lamb stew," and the like, shall contain not less than 25 percent of meat computed on the weight of the fresh meat.

(31) Product labeled "tamales" shall be prepared with at least 25 percent meat computed on the weight of the uncooked fresh meat in relation to all ingredients of the tamales. When tamales are packed in sauce or gravy, the name of the product shall include a prominent reference to the sauce or gravy, for example "Tamales with Sauce," or "Tamales with Gravy". Product labeled "Tamales with Sauce" or "Tamales with Gravy" shall contain not less than 20 percent meat, computed on the weight of the uncooked fresh meat in relation to the total ingredients making up the tamales and sauce or the tamales and gravy.

(32) Spaghetti with meat balls and sauce, spaghetti with meat and sauce, and similar product, shall contain not less than 12 percent of meat computed on the weight of the fresh meat. The presence of the sauce or gravy constituent shall be declared prominently on the label as part of the name of the product. Meat balls may be prepared with not more than 12 percent, singly or collectively, of farinaceous material, soya flour, dried skim milk, and the like.

(33) Spaghetti sauce with meat shall contain not less than 6 percent of meat computed on the weight of the fresh meat.

(34) Scrapple shall contain not less than 40 percent of meat and/or meat byproducts computed on the basis of the fresh weight, exclusive of bone. The meal or flour used may be derived from grain and/or soybeans.

(35) Hamburger shall consist of chopped fresh beef, with or without the addition of beef fat as such and/or of seasoning, and shall not contain more than 30 percent of fat.

(36) Liver sausage, liver loaf, liver paste, liver cheese, liver pudding, liver spread, and the like shall contain not less than 30 percent of liver computed on the weight of the fresh liver.

(37) Product labeled "ham spread," "tongue spread," and the like, shall contain not less than 50 percent of the meat ingredient named computed on the weight of the fresh meat. Other meat and fat may be used to give the desired spreading consistency provided it does not detract from the character of the named spread.

(38) Deviled ham may contain added ham fat: Provided, That the total fat content shall not exceed 35 percent of the finished product. The moisture content of deviled ham, deviled tongue, and the like, shall not exceed that of the fresh unprocessed meat.

(39) Potted meat food product and deviled meat food product shall not contain cereal,

vegetable flour, dried skim milk or similar substance. The amount of water added to potted meat food product and deviled meat food product shall be limited to that necessary to replace moisture lost during processing.

(40) Pork sausage and breakfast sausage, whether fresh, smoked, or canned, shall not be made with product which, in the aggregate for each lot, contains more than 50 percent trimmable fat; that is, fat which can be removed by thorough, practicable trimming and sorting.

(41) Cooked, cured, or pickled pigs feet, pigs knuckles, and the like, shall be labeled to show that the bones remain in the product, if such be the case. The designation "semi-boneless" shall not be used if less than 50 percent of the total weight of bones has been removed.

(42) Canned product labeled "Corned Beef" and canned product labeled "Roast Beef Parboiled and Steam Roasted" shall be prepared so that the weight of the finished product shall not exceed 70 percent by weight of the fresh beef, plus salt and flavoring material included in the product. Beef cheek meat and beef head meat from which the overlying glandular and connective tissues have been removed, and beef heart meat, exclusive of the heart cap, may be used individually or collectively to the extent of 5 percent of the meat ingredient in the preparation of canned product labeled "Corned Beef" and canned product labeled "Roast Beef Parboiled and Steam Roasted". When beef cheek meat, beef head meat, and beef heart meat are used in the preparation of these products, their presence shall be reflected in the statement of ingredients as required.

(43) When monoglycerides and diglycerides are added to rendered animal fat or a combination of such fat and vegetable fat, there shall appear on the label in a prominent manner and contiguous to the name of the product a statement such as "With Monoglycerides and Diglycerides," "Monoglycerides and Diglycerides Added," "With Diglycerides and Monoglycerides" or "Diglycerides and Monoglycerides Added" as the case may be.

(44) Canned product labeled "Tripe with Milk" shall be prepared so that the finished canned article, exclusive of the cooked-out juices and milk, will contain at least 65 percent tripe. The product shall be prepared with not less than 10 percent milk.

(45) Product labeled "Beans with Frankfurters in Sauce," "Sauerkraut with Wieners and Juice," and the like, shall contain not less than 20 percent frankfurters or wieners computed on the weight of the smoked and cooked sausage prior to its inclusion with the beans or sauerkraut.

(46) Product labeled "Lima Beans with Ham in Sauce," "Beans with Ham in Sauce," "Beans with Bacon in Sauce," and the like, shall contain not less than 12 percent ham or bacon computed on the weight of the smoked ham or bacon prior to its inclusion with the beans and sauce.

(47) Product labeled "Chow Mein Vegetables with Meat" and "Chop Suey Vegetables with Meat" shall contain not less than 12 percent meat computed on the weight of the uncooked fresh meat prior to its inclusion with the other ingredients.

(48) Products labeled "Pork with Barbecue Sauce" and "Beef with Barbecue Sauce" shall contain not less than 50 percent meat computed on the weight of the cooked and trimmed meat. The weight of the cooked meat used in this calculation shall not exceed 70 percent of the uncooked weight of the meat. If uncooked meat be used in formulating the product, they shall contain at least 72 percent meat computed on the weight of the fresh uncooked meat. When cereal, vegetable flour, dried skim milk or similar substances are used in preparing the products, such fact shall be prominently stated as a part of the name of the product.

(49) The weight of smoked products such as hams, pork shoulders, pork shoulder picnics, pork shoulder butts, beef tongues, and the like, except hams, pork shoulder picnics, and similar products prepared for canning shall not exceed the weight of the fresh uncured

article. Hams, pork shoulder picnics, and similar products prepared for canning shall be prepared to conform to the limitations provided in the case of ham for canning.

(50) The terms "Animal Fat" and "Meat Fat" may be used synonymously to identify rendered fats obtained from cattle, sheep, swine, or goats in the name of product and ingredient statement for such meat food products as shortening and uncolored oleomargarine. The terms "Animal Fat" or "Meat Fat" shall not be used to identify such well known single commodities as lard, rendered pork fat, oleo oil, oleo stearin, oleo stock and the like when prepared and packed as such.

(51) "Beef with Gravy" and "Gravy with Beef" shall not be made with beef which, in the aggregate for each lot contains more than 30 percent trimmable fat, that is, fat which can be removed by thorough practical trimming and sorting.

(52) The application of curing solution to beef briskets shall not result in an increase in the weight of the finished cured product of more than 20 percent over the weight of the fresh uncured briskets. The application of curing solution to other beef cuts, such as navals, clods, middle ribs, rumps and the like, which are intended for bulk corned beef shall not result in an increase in the weight of the finished cured product of more than 10 percent over the weight of the fresh uncured meat.

(53) Colored oleomargarine or colored margarine packed for retail sale shall be in containers not exceeding one-pound capacity.

(i) The word "oleomargarine" or "margarine" shall appear on each principal display panel of the container in type or lettering at least as large and in at least the same prominence as any other type or lettering appearing on such container.

(ii) A full and accurate statement of all the ingredients contained in such oleomargarine or margarine shall be prominently and informatively displayed contiguous to the word "oleomargarine" or "margarine" wherever such word is featured on the container. The ingredients shall be shown by their common or usual name and be arranged in the order of their predominance. Collective terms such as "animal fat" and "vegetable fat" shall not be used but the specific fat, oil or stearin shall be shown.

(iii) Each part of the contents of the container shall be enclosed in a wrapper bearing the word "oleomargarine" or "margarine" in type or lettering not smaller than 20-point type.

(iv) Wrapped quarter pound sticks or similar units of such oleomargarine or margarine packaged together in a container may constitute units for retail sale and they shall be individually wrapped and labeled in accordance with subdivision (i), (ii), and (iii) of this subparagraph.

(54) The preparation of cooked cured product such as hams, pork shoulders, pork shoulder picnics, pork shoulder butts, and pork loins, either by moist or dry heat, shall not result in the finished cooked article weighing more than the fresh uncured product; that is, the weight of the finished cooked article plus the weight of the skin, bones, fat, and trimmings removed during the preparation shall not exceed the weight of the fresh uncured product.

(55) Product labeled "Pressed Ham," and "Pressed Ham with Natural Juices," may contain finely chopped ham shank meat to the extent of 25 percent over that normally present in the boneless ham. The weight of the cured chopped ham prior to processing shall not exceed the weight of the fresh uncured ham, exclusive of the bones and fat removed in the boning operations, plus the weight of the curing ingredients and 3 percent moisture.

(56) When approved proteolytic enzymes are used on steaks or other meat cuts which are frozen or cooked within the official establishment where they are produced, there shall appear on the labels of the frozen or cooked cuts, contiguous to the name of the products, a prominent descriptive statement such as "Dipped in a Solution of Papain," to indicate the use of such enzymes.

(d) When a statement of quantity of contents is shown on a label it shall not be false or deceptive. Except as provided in regulation on "Product for Foreign Commerce," it shall meet the following requirements: It shall represent in terms of avoirdupois weight or liquid measure

the quantity of product in the package exclusive of materials packed with it. Where no general consumer usage to the contrary exists, the statements shall be in terms of liquid measure, if the product be liquid, or in terms of weight if the product be solid, semisolid, viscous, or a mixture of solid and liquid. Unless the statement be so qualified as to show that it expresses the minimum quantity, it shall be taken to express the actual quantity. When the statement expresses the minimum quantity, no variation below the stated minimum shall be permitted, and variations above the stated minimum shall be no greater than consistent with filling the container to the stated minimum in accordance with good commercial practice. When the statement expresses actual quantity, variation incident to packaging in accordance with good commercial practice shall be allowed but the average shall not be less than the quantity stated.

Labeling product prepared with artificial coloring, artificial flavoring, or preservative. Product which bears or contains any artificial coloring, artificial flavoring, antioxidants, or preservative shall bear labeling stating that fact.

(a) Artificial coloring of edible fats shall be declared on the label in a prominent manner and contiguous to the name of the product by the words "artificially colored".

(b) (1) When product is placed in casing to which artificial coloring is applied, as permitted under these regulations, there shall appear on the label, in a prominent manner and contiguous to the name of the product, the words "artificially colored".

(2) If the casing be removed from product at an official establishment and there is evidence of the artificial coloring on the surface of the product, there shall appear on the label in a prominent manner and contiguous to the name of the product, the words, "artificially colored".

(3) When the casing is colored prior to its use as a covering for product, the color shall be of a kind and so applied as not to be transferable to the product and not to be misleading or deceptive with respect to color, quality, or kind of product enclosed in the casing, and no reference to color need appear on the label.

(c) When any artificial flavoring is permitted to be added to product there shall appear on the label in prominent letters and contiguous to the name of the product the words "artificially flavored," and the ingredient statement shall identify it as an artificial flavoring.

(d) When an antioxidant is added to product as permitted under this chapter there shall appear on the label in prominent letters and contiguous to the name of product, a statement showing that fact and the purpose for which it is added, such as, "oxygen interceptor added to improve stability," except as otherwise provided in this chapter.

(e) Containers of meat packed in borax or other preservatives for export to a foreign country which permits the use of such preservatives shall, at the time of packing, be marked "for export," followed on the next line by the words "packed in preservative," or such equivalent statement as may be approved for this purpose by the Director of Division, and directly beneath this there shall appear the word "establishment" or abbreviation thereof, followed by the number of the establishment at which the product is packed. The complete statement shall be applied in a conspicuous location and in letters not less than 1 inch in height.

Reuse of inspection marks; reuse of containers bearing marks of inspection, labels, etc.; requirements regarding. (a) No inspection legend which has been previously used shall be used again for the identification of any product, except as provided for in paragraph (b) of this section.

(b) All stencils, marks, labels, or other devices on previously used containers, whether relating to any product or otherwise, shall be removed or obliterated before such containers are used for any product, unless such stencils, marks, labels, or devices correctly indicate the article to be packed therein and such containers are refilled under the supervision of a Division employee.

Labeling, filling of containers, handling of labeled products to be only in compliance with regulations. (a) All labeling of product required to be inspected by Division employees shall be in compliance with the regulations of this chapter.

(b) No person shall apply or affix, or cause to be applied or affixed, any label to any product prepared or received in an official establishment, or to any container thereof, except in compliance with the regulations of this chapter.

(c) No person shall, in an official establishment, fill or cause to be filled, in whole or in part, any container with any product required by the regulations of this chapter to bear a label, except in compliance with the regulations of this chapter.

(d) No person shall remove or cause to be removed from an official establishment any product bearing a label unless such label be in compliance with the regulations of this chapter.

Relabeling product, requirements regarding. When it is claimed by an official establishment that some of its labeled product which has been transported to a location other than an official establishment, is in need of relabeling on account of the labels having become mutilated or otherwise damaged, the requests for relabeling the product shall be sent to the Director of Division and accompanied with a statement of the reasons therefor. Labeling material intended for relabeling inspected and passed product shall not be transported from an official establishment until permission has been received from the Director of Division. The relabeling of inspected and passed product with official labels shall be done under the supervision of an inspector of the Division. The establishment shall reimburse the Division, in accordance with regulations of the United States Department of Agriculture, for any cost involved in supervising the relabeling of such product.

Distribution of labels bearing an inspection legend. Labels, wrappers, and cartons bearing an inspection legend with or without the establishment number may be transported from one official establishment to another provided such shipments be made with the permission and under the supervision of the inspector in charge at the station of origin, who will notify the inspector in charge at destination concerning the date of shipment of the labeling material and the character and quantity of the materials involved. No such material shall be used at the establishment to which it is shipped unless it conforms with the requirements of this chapter.

Rescindment of label approvals. Once a year or oftener if necessary, each official establishment should submit to the Director of Division, in quadruplicate, a list of approvals for labels that have become obsolete, accompanied with a statement that such approvals are no longer desired. The approvals shall be identified by the number, the date of approval, and the name of product or other designation showing the class of material.

Reinspection of products; frozen products. All products, whether fresh, cured, or otherwise prepared, even though previously inspected and passed, shall be reinspected by division employees as often as may be necessary in order to ascertain whether they are sound, healthful, wholesome, and fit for human food at the time they leave official establishments. If upon reinspection any article be found to have become unsound, unhealthful, unwholesome, or in any way unfit for human food, the original mark, stamp, or label thereon shall be removed or defaced and the article condemned: Provided, That (1) If an article becomes soiled or unclean by falling on the floor or in any other accidental way, it may be cleaned (included trimming, if necessary) and presented for reinspection.

(2) When an article is found to be affected by any unsound or unwholesome condition designated by the Director of Division as being capable of rehandling by approved method for food purposes, the official establishment may be permitted to rehandle if necessary steps are immediately taken in a manner prescribed by him. Included are such conditions as articles found to have absorbed a foreign odor, to contain mold or similar substance, and rendered animal fat in which there is present tank water in first stages of sourness. If upon first inspection the article be found to be sound and wholesome it shall be passed for human food; otherwise it shall be condemned.

(3) Product, such as pork tenderloins, brains, sweetbreads, stews, chop suey, etc., shall not be packed in hermetically sealed metal or glass containers, unless subsequently heat processed or otherwise treated to preserve the product in a manner approved by the Director of Division.

Care shall be taken to see that product is in good condition when placed in freezers. If there be doubt as to the soundness of any frozen product, the inspector will require the defrosting and reinspection of a sufficient quantity thereof to determine its actual condition.

Frozen product may be defrosted in water or pickle in a manner and with the use of facilities which are acceptable to the inspector in charge. Before such product is defrosted, a careful examination shall be made to determine its condition. If necessary, this examination shall include defrosting of representative samples by means other than in water or pickle.

Attention should be given particularly to the first drawoff from the bottoms of tank cars where a tank-water-sour condition is sometimes found.

Tagging products "U.S. retained" on reinspection; disposition thereof. A "U.S. retained" tag shall be placed by a division employee at the time of reinspection on all products or the containers thereof which are suspected on reinspection at an official establishment or in the possession of such establishment of being unsound, unhealthful, unwholesome, or in any way unfit for human food. The employee who affixes the tag shall record the tag number and the kind and amount of the article retained. Such tag shall accompany such article to the retaining room or other special place for final inspection. When the final inspection is made, if the article be condemned, the original mark, stamp, or label thereon shall be removed or defaced and the inspector shall stamp on or write across the face of the retained tag the phrase "U.S. inspected and condemned," and this tag shall accompany such article into the tank. The inspector shall make a complete record of the transaction and shall report his action to the inspector in charge. If, however, upon final inspection the article be passed for food, the inspector shall remove the retained tag, record the transaction, and report his action to the inspector in charge.

Unsound product bearing inspection mark found outside of official establishments. Division employees shall inform local representatives of the Food and Drug Administration, or responsible State or municipal officials, and report to the Director of Division regarding any product which bears, or the container of which bears, the inspection legend, discovered by them outside of official establishments, and which is unsound, unhealthful, unwholesome, or in any way unfit for human food.

Product entering official establishment; identification as inspected and passed; disposition; shipping in commerce. Except as provided, no product shall be brought into an official establishment unless it has been previously inspected and passed by a division employee, nor unless it can be identified by marks, seals, brands, or labels as having been so inspected and passed, nor, except as provided for imported products, if it has been processed elsewhere than in an official establishment. All products brought into an official establishment in compliance with the regulations shall be identified and reinspected at the time of receipt, and be subjected to further reinspection in such manner and at such times as may be deemed necessary. If upon such reinspection any article be found to be unsound, unhealthful, unwholesome, or otherwise unfit for human food, the original mark, stamp, or label shall be removed or defaced and the article condemned.

Any product which has been inspected and passed under the regulations and which bears the inspection legend may be shipped in interstate or foreign commerce, provided that it be sound, healthful, wholesome, and fit for human food and has not been processed, reprocessed or changed elsewhere than in an official establishment in any manner so as to alter the character of the product.

Designation of places of receipt of returned products for reinspection. Every official establishment shall designate, with the approval of the inspector in charge, a dock or place at which returned products shall be received, and such products shall be received only at such dock or

place and shall be inspected there by a division employee before further entering the establishment.

Processes to be supervised; containers, equipment, processes of manufacture to be clean and sanitary; substances to be clean and wholesome. (a) All processing used in curing, pickling, rendering, canning, or otherwise preparing any product in official establishments shall be supervised by division employees. No fixtures or appliances, such as tables, trucks, trays, tanks, vats, machines, implements, cans or containers of any kind, shall be used unless they be of such materials and construction as will not contaminate the product and are clean and sanitary. All steps in the processes of manufacture shall be conducted carefully and with strict cleanliness in rooms or compartments separate from those used for inedible products. (1) All containers which are intended to be hermetically sealed shall be washed as required herein below immediately before filling, except that the hermetically sealed cans in which lard is shipped may be examined immediately before being filled and if found to be acceptably clean, need not be washed.

(2) Pumps, pipes, conductors, and fittings used to conduct milk, skim milk, cream, or mixtures of these in the manufacture of oleomargarine shall be of sanitary construction, with smooth inner and outer surfaces of noncorrosive material or coated with nickel, tin, or other approved material, readily demountable for cleaning, and shall be kept clean and sanitary.

(3) Equipment may be used interchangeably for the preparation of lard and rendered pork fat which are to be labeled as such. The Director of Division may grant permission for the restricted dual use of such equipment for the preparation of other products. The pipes and equipment used for edible fats shall be so arranged that the identity of the product will be maintained until the product be properly labeled.

(4) The only animal casings that may be used as containers of product are those from cattle, sheep, swine or goats.

(5) Casings for products shall be carefully inspected by Division employees. Only those casings which have been carefully washed and thoroughly flushed with clean water immediately before stuffing, are suitable for containers, are clean, and are passed on such inspection shall be used, except that preflushed animal casings packed in salt or salt and glycerine solution or other approved medium may be used without additional flushing provided they are found to be clean and otherwise acceptable and are thoroughly rinsed before use.

(6) Beef rounds, beef bungs, beef middles, beef bladders, calf rounds, hog bungs, hog middles, and hog stomachs which are to be used as containers of meat food product shall be presented for inspection turned with the fat surface exposed.

(7) Portions of casings which show infestation with Oesophagostomum or other nodule-producing parasite and weasands infested with the larvae of Hypoderma lineatum, shall be rejected, except that when the infestation is slight and the nodules and larvae are removed, the casing or weasand may be passed.

(8) The fermenting of intestines is not permitted in official establishments. The stripping and sliming of intestines shall be performed in a clean manner.

(9) Hog and sheep casings intended for use as containers of product may be treated by soaking in or applying thereto sound, fresh pineapple juice or a sound solution containing fresh pineapple juice or papain or bromeline or pancreatic extract to permit the enzymes contained in these substances to act on the casings to make them less resistant. The casings shall be handled in a clean and sanitary manner throughout and the treatment shall be followed by washing and flushing the casings with water sufficiently to effectively remove the substance used and terminate the enzymatic action.

(b) All substances and ingredients used in the manufacture or preparation of any product shall be clean, sound, healthful, wholesome, and otherwise fit for human food.

(1) On account of the invariable presence of bone splinters, detached spinal cords shall not be used in the preparation of edible product other than for rendering where they constitute a suitable raw material.

(2) Care shall be taken to remove bones and parts of bones from product which is intended for chopping.

(3) Heads for use in the preparation of meat food products shall be split and the bodies of the teeth, the turbinate and ethmoid bones, ear tubes, and horn butts removed, and the heads then thoroughly cleaned.

(4) Kidneys for use in the preparation of meat food products shall first be freely sectioned and then thoroughly soaked and washed. All detached kidneys, including beef kidneys detached with kidney fat, shall be inspected before being used in or shipped from the establishment.

(5) Testicles if handled as an edible product may be shipped from the establishment as such, but they shall not be used as an ingredient of a meat food product.

(6) Cattle paunches and hog stomachs for use in the preparation of meat food products shall be thoroughly cleaned on all surfaces and parts immediately after being emptied of their contents, which shall follow promptly their removal from the carcasses.

(7) Tonsils shall be removed and shall not be used as ingredients of meat food products.

(8) Hog blood shall not be used as an ingredient of meat food products. No blood which comes in contact with the surface of the body of an animal or is otherwise contaminated shall be collected for food purposes. Only blood from animals the carcasses of which are inspected and passed may be used for meat food products. The defibrination of blood intended for food purposes shall not be performed with the hands.

(9) No prohibited dye, chemical, preservative, or other substance shall be brought into or kept in an official establishment for use as an ingredient of human food or animal feed.

(10) Intestines shall not be used as ingredients of meat food products.

(11) Clotted blood shall be removed from hog hearts before they are shipped from the establishment or used in the preparation of a meat food product.

Use in preparation of meat food products of chemicals, antioxidants, coloring matter, flavoring, water, ice, cereal, vegetable starch, nonfat dry milk, etc. (a) No product shall contain any substance which impairs its wholesomeness or which is not approved by the Director of Division.

(b) There may be added to product, with appropriate declaration as required herein, common salt, approved sugars (sucrose, cane or beet sugar), maple sugar, dextrose, invert sugar, honey, corn syrup solids, corn syrup and glucose syrup, wood smoke, vinegar, flavorings, spices, sodium nitrate, sodium nitrite, potassium nitrate (saltpetre) and potassium nitrite.

(c) Monoglycerides and diglycerides may be added to rendered animal fat or a combination of such fat and vegetable fat with appropriate declaration.

(d) With appropriate declaration, the following preservatives may be added, in the amounts indicated, to rendered animal fat or a combination of such fat and vegetable fat:

(1) Resin guaiac not to exceed 1/10 of 1 percent; or

(2) Nordihydroguaiaretic acid not to exceed 1/100 of 1 percent; or

(3) Tocopherols not to exceed 3/100 of 1 percent. (A 30-percent concentration of tocopherols in vegetable oils shall be used when added as a preservative to products designated

as "lard" or "rendered pork fat"); or

(4) Lecithin: Provided, That nothing in this paragraph shall prevent the use of this substance as an emulsifier as approved by the Director of Division; or

(5) Butylated hydroxyanisole (a mixture of 2-tertiary butyl 4-hydroxyanisole and 3-tertiary butyl 4-hydroxyanisole) not to exceed 1/100 of 1 percent; or

(6) Butylated hydroxytoluene (2,6 ditertiary butyl paracresol) (2,6 di-tertiary butyl 4-methyl phenol) not to exceed 1/100 of 1 percent; or

(7) Propyl gallate not to exceed 1/100 of 1 percent; or

(8) Combinations of two or more of the antioxidants listed herein not to exceed 2/100 of 1 percent; or

(9) Citric acid and/or phosphoric acid and/or monoisopropyl citrate not to exceed 1/100 of 1 percent, either alone or in combination with the antioxidants listed herein.

(e) To facilitate chopping and/or to dissolve the usual curing ingredients, water or ice may be used in the preparation of luncheon meat and meat loaf, however, the total amount of water used shall not exceed 3 percent of the ingredients going into the preparation of the product and its presence shall be declared as required.

(f) Except as otherwise provided, sausage shall be prepared with meat, or meat and meat byproduct, seasoned with condimental proportions of condimental substances.

(g) Under appropriate declaration, sausage may contain not more than 3 1/2 percent, individually or collectively, of cereal, vegetable starch, starchy vegetable flour, soya flour, dried skim milk, or dried milk.

(h) For the purpose of facilitating chopping and mixing, and under appropriate declaration, water or ice may be used in the preparation of sausage which is not cooked, in an amount not to exceed 3 percent of the total ingredients used. Sausage of the kind which is cooked, such as frankfurter, vienna and bologna, may contain not more than 10 percent of added water or moisture.

(i) Bicarbonate of soda, caustic soda, sodium carbonate, diatomaceous earth, fuller's earth, carbon, acetic acid, tannic acids, agents used exclusively as catalyzers such as nickel preparations, and such other substances as may be approved by the Director of Division, may be used in the preparation of rendered fats: Provided, That they be eliminated during the process of manufacturing.

(j) Caustic soda, sodium carbonate (soda ash or sal soda), trisodium phosphate, or sodium metasilicate, or a combination of these substances, or lime, or a combination of lime and sodium carbonate, and/or a solution of hydrogen peroxide, may be used in the preparation of tripe: Provided, That immediately following the treatment the tripe be thoroughly washed with clear water and the added substances removed.

(k) The use of sodium nitrite, potassium nitrite, sodium nitrate, or combinations of nitrite and nitrate, shall not result in the presence of more than 200 parts per million of nitrite in the finished product. Supplies of sodium nitrite and potassium nitrite and mixtures containing them must be kept securely under the care of a responsible employee of the establishment. The specific nitrite content of such supplies must be known and clearly marked accordingly. The maximum amounts of sodium nitrite and/or potassium nitrite which may be used are as follows:

2 pounds in 100 gallons of pickle
1 ounce for each 100 pounds of meat in dry salt, dry cure, or box cure
1/4 ounce in 100 pounds of chopped meat and/or meat byproducts.

(l) Harmless synthetic flavoring may be added to products for which they are approved by the Director of Division, and declared as "artificial flavoring"

(m) Coloring matter and dyes which are approved by the Director of Division when declared may be mixed with rendered fats, applied to animal and artificial casings, and applied to such casings enclosing product: Provided, That there be no penetration of the

coloring matter or dye into the product. The presence of a visible ring of dyed product appearing around the periphery of the cut surface is evidence of penetration. And Provided further, That when coloring matter or dyes be added to meat fat shortening containing artificial flavoring, the product shall be packed in conventional, round, shortening containers having a capacity no greater than 3 lbs. The following coloring matters and dyes are acceptable:

(1) The natural coloring matters alkanet, annatto, carotene, cochineal, green chlorophyl, saffron, and turmeric.

(2) Coal-tar dyes as follows, subject also to certification by the manufacturer and the furnishing of authoritative evidence to the inspector in charge that the dyes have been certified under the Federal Food, Drug, and Cosmetic Act for use in connection with foods:

Name	Former Name
FD&C Blue No. 1	Brilliant Blue FCF
FD&C Blue No. 2	Indigotine
FD&C Green No. 1	Guinea Green B
FD&C Green No. 2	Light Green SF Yellowish
FD&C Green No. 3	Fast Green FCF
FD&C Orange No. 1	Orange 1
FD&C Orange No. 2	Orange SS
FD&C Red No. 1	Ponceau 3R
FD&C Red No. 2	Amaranth
FD&C Red No. 3	Erythrosine
FD&C Red No. 4	Ponceau SX
FD&C Red No. 32	Oil Red XO
FD&C Yellow No. 1	Naphthol Yellow S
FD&C Yellow No. 2	Naphthol Yellow S -Potassium Salt
FD&C Yellow No. 3	Yellow AB
FD&C Yellow No. 4	Yellow OB
FD&C Yellow No. 5	Tartrazine
FD&C Yellow No. 6	Sunset Yellow FCF

(3) Mixture of two or more dyes mentioned in (1) and (2) above, or a mixture of one or more of the dyes with harmless inert materials, such as common salt or sugar.

(n) The preparation of a ham for canning shall not result in an increase in weight of more than 8 percent over the weight of the fresh uncured ham at the time of canning, plus the weight of the skin, bones, fat, and trimmings removed from the ham, shall not exceed 108 percent of the weight of the fresh uncured ham.

(o) For the purpose of preventing coagulation, citric acid or sodium citrate with or without water may be added to fresh beef blood in an amount not to exceed 2/10 of 1 percent of the total mixture. When water is used to make a solution of the citric acid or sodium citrate added to the beef blood, not more than two parts of water to one part of citric acid or sodium citrate shall be used.

(p) Harmless bacterial starters of the acidophilus type may be used in the preparation of such kinds of sausage as thuringer, lebanon bologna, cervelat, salami and pork roll in an amount not to exceed 1/2 of 1 percent. When used, the harmless bacterial starter shall be included in the list of ingredients in the order of its predominance as required.

(q) Corn syrup solids, corn syrup, or glucose syrup shall not be used individually or collectively in an amount exceeding 2 percent (calculated on a dry basis) of all of the ingredients used in preparing such meat food products as sausage, hamburger, meat loaf, luncheon meat, chopped ham, or pressed ham.

(r) Disodium phosphate, sodium hexametaphosphate, sodium tripolyphosphate, sodium pyrophosphate, and sodium acid pyrophosphate, may be added to the pumping pickle for cured hams and pork shoulder picnics and may be used in the preparation of canned chopped ham,

provided such use shall not result in more than 1/2 of 1 percent of added phosphate in the finished product and provided that the maximum amount of such phosphate which may be so used be as follows:

(1) Pumping pickle shall not contain more than 5 percent of such phosphate. When dissolved in pumping pickle, a small quantity of a crystalline precipitate material may be formed. Such pickle shall be filtered or the precipitate allowed to settle so that only the clear solution is injected into product.

(2) With appropriate declaration, as required in this subchapter, such phosphate may be used in the preparation of canned chopped ham in an amount not to exceed 8 ounces for each 100 pounds of the fresh uncured comminuted ham.

(s) Ascorbic acid or sodium ascorbate may be used in the preparation of cured pork and beef products and comminuted meat food products as follows:

(1) Pickle used for pumping, curing, or packing pork and beef products shall not contain more than 7 1/2 ounces of ascorbic acid or sodium ascorbate to each 100 gallons of pickle.

(2) With appropriate declaration, as required in this subchapter, ascorbic acid or sodium ascorbate may be used in the preparation of cooked, cured, comminuted meat food products in amounts not to exceed 3/4 ounce of ascorbic acid or 7/8 ounce of sodium ascorbate for each 100 pounds fresh meat or meat food product. A solution containing not more than 5 percent ascorbic acid or sodium ascorbate in water or brine may be applied to the outer surface of sliced or unsliced cured pork and beef products and comminuted meat food products prior to packaging. The use of such solution shall not result in the addition of a significant amount of moisture to the product.

(t) With appropriate declaration as required under this chapter, not more than 3/1000 of 1 percent of butylated hydroxyanisole and 1/1000 of 1 percent of citric acid may be used in unsmoked dry sausage which is held during preparation in a drying room for purposes of trichinae treatment for the periods prescribed in this chapter.

Preservatives and other substances permitted in product for export only; handling; such product not to be used for domestic food purposes. (a) Preservative and other substances not otherwise permitted in this chapter may be used in the preparation and packing of product intended for export provided the product (1) accords to the specifications of the foreign purchaser, (2) is not in conflict with the laws of the country to which it is intended for export, and (3) is labeled on the outside of the shipping container to show that it is intended for export, and is otherwise labeled as required by this chapter for such export product.

(b) The preparation and packing of export product as provided for in paragraph (2) of this section shall be done in a manner acceptable to the inspector in charge so that the identity of the export product be maintained conclusively and the preparation of domestic product be adequately protected. The preservative or other substances not permitted in domestic product shall be stored in a room or compartment separate from areas used to store other supplies and shall be held under Division lock. Use of the preservative or other substances shall be under the personal supervision of a Division employee.

(c) The packing of all articles shall be conducted under the personal supervision of a division employee.

(d) No article prepared or packed for export shall be sold or offered for sale for domestic use or consumption, but unless exported shall be destroyed for food purposes under the personal supervision of a division employee.

(e) The contents of the container of any article prepared or packed for export shall not be removed, in whole or in part, prior to exportation, except under the supervision of a division employee. If such contents be removed prior to exportation, then the article shall be either repacked in accordance with the above, or destroyed for food purposes under the personal supervision of a division employee.

(f) Permission must be obtained from the Director of Division before meats packed in borax are shipped from one official establishment to another or to an unofficial establishment

for storage, except such meat prepared for the account of Federal agencies.

(g) At all times, the identity of meat to which borax has been added shall be effectively maintained. In no case shall such meat, nor any trimmings or fat derived from such meat, whether unwashed or washed, or otherwise treated, be diverted to domestic use.

(h) Salt used for bulking meat previously packed in borax may not again be used in an edible products department other than in connection with the packing of meat in borax. If available, only metal equipment should be used for handling such meat. Particularly effective cleansing will be required if wooden equipment, such as trucks, washing vats, etc., be used. Boxes from which boraxed meat has been removed may be used for repacking meat in borax, but their use as containers for other meat will be dependent upon the effective removal of all traces of borax.

(i) The following instructions pertain to export cured pork packed in borax for the account of Federal agencies:

The meat may be packed in borax in a room in which there is borax-free meat: Provided, That proper care be taken to see that the borax-free meat not be affected by the borax. Under the same condition, meat packed in borax may be received, unpacked, defrosted, soaked, washed, smoked, and repacked in a room where there is other meat. However, meat originally packed in borax shall at all times be subject to the restrictions of meat so packed, even though repacked without borax. After packing or repacking, borax meat may be stored in a room with meat not packed in borax: Provided, A reasonable degree of separation be maintained between the two classes of products.

Samples of products, water, dyes, chemicals, etc., to be taken for examination. Samples of products, water, dyes, chemicals, preservatives, spices, or other articles in any official or exempted establishment shall be taken, without cost to the division, for examination, as often as may be deemed necessary for the efficient conduct of the inspection.

Prescribed treatment of pork and products containing pork to destroy trichinae. (a) All forms of fresh pork, including fresh unsmoked sausage containing pork muscle tissue, and pork such as bacon and jowls, other than those covered by paragraph (b) of this section, are classed as products that are customarily well cooked in the home or elsewhere before being served to the consumer. Therefore, the treatment of such products for the destruction of trichinae is not required.

(b) Products named in this paragraph, and products of the character thereof, containing pork muscle tissue (including hearts, pork stomachs and pork livers), or the pork muscle tissue which forms an ingredient of such products, shall be effectively heated, refrigerated, or cured at a federally inspected establishment to destroy any possible live trichinae: bologna; frankfurts; viennas; smoked sausage; knoblauch sausage; mortadella; all forms of summer or dried sausage, including mettwurst; cooked loaves; roasted, baked, boiled, or cooked hams, pork shoulders, or pork shoulder picnics; Italian-style hams; Westphalia-style hams; smoked boneless pork shoulder butts; cured meat rolls; capocollo (capicola, capacola); coppa; fresh or cured boneless pork shoulder butts, hams, loins, shoulders, shoulder picnics, and similar pork cuts, in casings or other containers in which ready-to-eat delicatessen articles are customarily enclosed (excepting Scotch-style hams); frozen breaded pork products over 1/2 inch in thickness; cured boneless pork loins; boneless back bacon; smoked pork cuts such as hams, shoulders, loins and pork shoulder picnics (excepting smoked hams and smoked pork shoulder picnics which are specially prepared for distribution in tropical climates or smoked hams delivered to the Armed Services). Cured boneless pork loins shall be subjected to prescribed treatment for destruction of trichinae prior to being shipped from the establishment where cured.

(c) The treatment shall consist of heating, refrigerating, or curing, as follows:

Heating: All parts of the pork muscle tissue shall be heated to a temperature not lower than 137° F., and the method used shall be one known to insure such a result. On account of

differences in methods of heating and in weights of products undergoing treatment, it is impracticable to specify details of procedures for all cases.

Procedures which insure the proper heating of all parts of the product shall be adopted. It is important that each piece of sausage, each ham, and other product treated by heating in water be kept entirely submerged throughout the heating period; and that the largest pieces in a lot, the innermost links of bunched sausage or other massed articles, and pieces placed in the coolest part of a heating cabinet or compartment or vat be included in the temperature tests.

Refrigerating. At any stage of preparation and after preparatory chilling to a temperature of not above 40° F. or preparatory freezing, all parts of the muscle tissue of pork or product containing such tissue shall be subjected continuously to a temperature not higher than one of those specified in Table 1, the duration of such refrigeration at the specified temperature being dependent on the thickness of the meat or inside dimensions of the container.

Table 1. Required Period of Freezing at Temperature Indicated

Temperature	Group 1	Group 2
° F.	Days	Days
5	20	30
-10	10	20
-20	6	12

Group 1 comprises product in separate pieces not exceeding 6 inches in thickness, or arranged on separate racks with the layers not exceeding 6 inches in depth, or stored in crates or boxes not exceeding 6 inches in depth, or stored as solidly frozen blocks not exceeding 6 inches in thickness.

Group 2 comprises product in pieces, layers, or within containers, the thickness of which exceeds 6 inches but not 27 inches, and product in containers including tierces, barrels, kegs, and cartons having a thickness not exceeding 27 inches.

The product undergoing such refrigeration or the containers thereof shall be so spaced while in the freezer as will insure a free circulation of air between the pieces of meat, layers, blocks, boxes, barrels, and tierces in order that the temperature of the meat throughout will be properly reduced to not higher than 5° F., - 10° F., or -20° F., as the case may be.

During the period of refrigeration, the product or lot thereof shall be kept separate from other products and in the custody of the division. Rooms or compartments equipped for being made secure with division lock or seal shall be provided. The rooms or compartments containing product undergoing freezing shall be equipped with accurate thermometers placed at or above the highest level at which the product undergoing treatment is stored and away from refrigerating coils. After the prescribed freezing has been finished, the product shall be kept under close supervision of an inspector until it is prepared in finished form or until it is transferred under division control to another establishment for preparation in finished form.

Pork which has been refrigerated as herein specified may be transferred to sealed railroad cars, sealed motortrucks, sealed wagons, or sealed closed containers to another official establishment at the same or another station for use in the preparation of meat and product of a kind customarily eaten without cooking by the consumer. The sealing of closed containers, such as boxes and slack barrels, shall be effected by cording and affixing thereto division seals, and such containers as tierces and kegs shall be held in division custody by sealing with wax impressed with a division metal brand. Railroad cars, motortrucks, and wagons shall, when necessary, be sealed with other meat in unsealed railroad cars, motortrucks, and wagons. Containers such as boxes, barrels, and tierces shall be plainly and conspicuously marked with a label or stencil furnished by the establishment, as follows: "Pork product - - - degrees F. - - - days' refrigeration," indicating the temperature at which the product was refrigerated and

length of time so treated. For each consignment there shall be promptly issued and forwarded to the inspector in charge at destination a report on the form entitled "Notice of Unmarked Meats Shipped in Sealed Cars," appropriately modified to show the character of the containers and that the contents are "Pork product - - - F. - - - days' refrigeration". A duplicate copy shall be retained in the station file.

Curing. Sausage may be stuffed in animal casings, hydrocellulose casings, or cloth bags. During any stage of treating the sausage for the destruction of live trichinae, except as provided in method 5, these coverings shall not be coated with paraffin or like substance, nor shall any sausage be washed during any prescribed period of drying. In the preparation of sausage, one of the following methods may be used:

Method No. 1. The meat shall be ground or chopped into pieces not exceeding three-fourths of an inch in diameter. A dry-curing mixture containing not less than 3 1/3 pounds of salt to each hundredweight of the unstuffed sausage shall be thoroughly mixed with the ground or chopped meat. After being stuffed, sausage having a diameter not exceeding 3 1/2 inches, measured at the time of stuffing shall be held in a drying room not less than 20 days at a temperature not lower than 45° F., except that in sausage of the variety known as pepperoni, if in casings not exceeding 1 3/8 inches in diameter measured at the time of stuffing, the period of drying may be reduced to 15 days. In no case, however, shall the sausage be released from the drying room in less than 25 days from the time the curing materials are added, except that sausage of the variety known as pepperoni, if in casings not exceeding the size specified, may be released at the expiration of 20 days from the time the curing materials are added. Sausage in casings exceeding 3 1/2 inches, but not exceeding 4 inches, in diameter at the time of stuffing, shall be held in a drying room not less than 35 days at a temperature not lower than 45° F., and in no case shall the sausage be released from the drying room in less than 40 days from the time the curing materials are added to the meat.

Method No. 2. The meat shall be ground or chopped into pieces not exceeding three-fourths of an inch in diameter. A dry-curing mixture containing not less than 3 1/3 pounds of salt to each hundredweight of the unstuffed sausage shall be thoroughly mixed with the ground or chopped meat. After being stuffed, the sausage having a diameter not exceeding 3 1/2 inches, measured at the time of stuffing, shall be smoked not less than 40 hours at a temperature not lower than 80° F., and finally held in a drying room not less than 10 days at a temperature not lower than 45° F. In no case, however, shall the sausage be released from the drying room in less than 18 days from the time curing materials are added to the meat. Sausage exceeding 3 1/2 inches, but not exceeding 4 inches, in diameter at the time of stuffing, shall be held in a drying room, following smoking as above indicated, not less than 25 days at a temperature not lower than 45° F. and in no case shall the sausage be released from the drying room in less than 33 days from the time the curing materials are added to the meat.

Method No. 3. The meat shall be ground or chopped into pieces not exceeding three-fourths of an inch in diameter. A dry-curing mixture containing not less than 3 1/2 pounds of salt to each hundredweight of the unstuffed sausage shall be thoroughly mixed with the ground or chopped meat. After admixture with the salt and other curing materials and before stuffing, the ground or chopped meat shall be held at a temperature not lower than 34° F. for not less than 36 hours. After being stuffed, the sausage shall be held at a temperature not lower than 34° F. for an additional period of time sufficient to make a total of not less than 144 hours from the time the curing materials are added to the meat, or the sausage shall be held for the time specified in a pickle-curing medium of not less than 50° strength (salometer reading) at a temperature not lower than 44° F. Finally, the sausage having a diameter not exceeding 3 1/2 inches, measured at the time of stuffing, shall be smoked for not less than 12 hours. The temperature of the smokehouse during this period at no time shall be lower than 90° F.; and for 4 consecutive hours of this period the smokehouse shall be maintained at a temperature not lower than 128° F. Sausage exceeding 3 1/2 inches, but not exceeding 4 inches in diameter at the time of stuffing shall be smoked, following the prescribed curing, for not less than 15 hours. The temperature of the smokehouse during the 15 hour period shall at no time be lower than 90° F., and for 7 consecutive hours of this period the smokehouse shall be maintained at a temperature not lower than 128° F. In regulating the temperature of the smokehouse for the treatment of sausage under the method, the temperature of 128° F. shall be attained gradually during a period of not less than 4 hours.

Method No. 4. The meat shall be ground or chopped into pieces not exceeding one-fourth of an inch in diameter. A dry-curing mixture containing not less than 2 1/2 pounds of salt to each hundredweight of the unstuffed sausage shall be thoroughly mixed with the ground or chopped meat. After admixture with the salt and other curing materials and before stuffing, the ground or chopped sausage shall be held as a compact mass, not more than 6 inches in depth, at a temperature not lower than 36° F. for not less than 10 days. At the termination of the holding period, the sausage shall be stuffed in casings or cloth bags not exceeding 3 1/2 inches in diameter, measured at the time of stuffing. After being stuffed, the sausage shall be held in a drying room at a temperature not lower than 45° F. for the remainder of a 35-day period, measured from the time the curing materials are added to the meat. At any time after stuffing, if a concern deems it desirable, the product may be heated in a water bath for a period not to exceed 3 hours at a temperature not lower than 85° F., or subjected to smoking at a temperature not lower than 80° F., or the product may be both heated and smoked as specified. The time consumed in heating and smoking, however, shall be in addition to the 35-day holding period specified.

Method No. 5. The meat shall be ground or chopped into pieces not exceeding three-fourths of an inch in diameter. A dry-curing mixture containing not less than 3 1/3 pounds of salt to each hundredweight of the unstuffed sausage shall be thoroughly mixed with the ground or chopped meat. After being stuffed, the sausage shall be held for not less than 65 days at a temperature not lower than 45° F. The coverings for sausage prepared according to this method may be coated at any stage of the preparation before or during the holding period with paraffin or other substance approved by the Director of Division.

Capocollo (capicola, capacola). Boneless pork butts for capocollo shall be cured in a dry-curing mixture containing not less than 4 1/2 pounds of salt per hundredweight of meat for a period of not less than 25 days at a temperature not lower than 36° F. If the curing materials be applied to the butts by the process known as churning, a small quantity of pickle may be added. During the curing period, the butts may be overhauled according to any of the usual processes of overhauling including the addition of pickle or dry salt if desired. The butts shall not be subjected during or after curing to any treatment designed to remove salt from the meat, except that superficial washing may be allowed. After being stuffed, the product shall be smoked for a period of not less than 30 hours at a temperature not lower than 80° F., and shall finally be held in a drying room not less than 20 days at a temperature not lower than 45° F.

Coppa. Bonelss pork butts for coppa shall be cured in a dry-curing mixture containing not less than 4 1/2 pounds of salt per hundred weight of meat for a period of not less than 18 days at a temperature not lower than 36° F. If the curing mixture be applied to the butts by the process known as churning, a small quantity of pickle may be added. During the curing period, the butts may be overhauled according to any of the usual processes of overhauling, including the addition of pickle or dry salt if desired. The butts shall not be subjected during or after curing to any treatment designed to remove salt from the meat, except that superficial washing may be allowed. After being stuffed, the product shall be held in a drying room not less than 35 days at a temperature not lower than 45° F.

Hams. In the curing of hams either of the following methods may be used:

Method No. 1. The hams shall be cured by a dry-salt curing process for not less than 40 days at a temperature not lower than 36° F. The hams shall be laid down in salt, not less than 4 pounds to each hundredweight of hams, the salt being applied in a thorough manner to the lean meat of each ham. When placed in cure, the hams may be pumped with pickle if desired. At least once during the curing process, the hams shall be overhauled and additional salt applied, if necessary, so that the lean meat of each ham is thoroughly covered. After removal from cure, the hams may be soaked in water at a temperature not higher than 70° F. for not more than 15 hours, during which time the water may be changed once; but they shall not be subjected to any other treatment designed to remove salt from the meat, except that superficial washing may be allowed. The hams shall finally be dried or smoked for not less than 10 days at a temperature not lower than 95° F.

Method No. 2. The hams shall be cured by a dry-salt curing process at a temperature

not lower than 36° F. for a period of not less than 3 days for each pound of weight (green) of the individual hams. The time of cure of each lot of hams placed in cure should be calculated on a basis of the weight of the heaviest ham of the lot. Hams cured by this method, before they are placed in cure, shall be pumped with pickle solution of not less than 100° strength (salometer), about 4 ounces of the solution being injected into the shank and a like quantity along the flank side of the body bone (femur). The hams shall be laid down in salt, not less than 4 pounds of salt to each hundredweight of hams, the salt being applied in a thorough manner to the lean meat of each ham. At least once during the curing process,the hams shall be overhauled and additional salt applied, if necessary, so that the lean meat of each ham is thoroughly covered. After removal from the cure, the hams may be soaked in water at a temperature not higher than 70° F. for not more than 4 hours, but shall not be subjected to any other treatment designed to remove salt from the meat, except that superficial washing may be allowed. The hams shall then be dried or smoked for not less than 48 hours at a temperature not lower than 80° F. and finally shall be held in a drying room for not less than 20 days at a temperature not lower than 45° F.

Boneless pork loins and loin ends. In lieu of heating or refrigerating to destroy trichinae in boneless loins, the loins shall be cured for a period of not less than 25 days at a temperature not lower than 36° F. by the use of one of the following methods:

Method No. 1. A dry-salt curing mixture containing not less than 5 pounds of salt to each hundredweight of meat.

Method No. 2. A pickle solution of not less than 80° strength (salometer) on the basis of not less than 60 pounds of pickle to each hundredweight of meat.

Method No. 3. A pickle solution added to the approved dry-salt cure provided the pickle solution be not less than 80° strength (salometer).

After removal from cure, the loins may be soaked in water for not more than 1 hour at a temperature not higher than 70° F. or washed under spray but shall not be subjected, during or after the curing process, to any other treatment designed to remove salt.

Following curing, the loins shall be smoked for not less than 12 hours. The minimum temperature of the smokehouse during this period at no time shall be lower than 100° F., and for 4 consecutive hours of this period the smokehouse shall be maintained at a temperature not lower than 125° F.

Finally, the product shall be held in a drying room for a period of not less than 12 days at a temperature not lower than 45° F.

General instruction. When necessary to comply with these instructions, the smokehouses, drying rooms, and other compartments used in the treatment of pork to destroy trichinae shall be suitably equipped, by the establishment, with accurate automatic recording thermometers. Inspectors in charge are authorized to approve for use in sausage smokehouses, drying rooms, and other compartments, such automatic recording thermometers as are found to give satisfactory service.

To insure the effective administration of the foregoing, inspectors who supervise the handling and treatment of pork to destroy live trichinae shall:

1) Recognize the importance of safeguarding the consumer and follow carefully the instructions concerning the treatment of pork to destroy trichinae.

2) Check the internal temperatures, with department thermometers, of all products subjected to the heating method.

3) Test frequently, with department thermometers, the reliability of establishment thermometers (including automatic recording thermometers) and reject for use any found to be inaccurate and unreliable.

4) Observe department thermometers carefully in order that none be used which have become defective or of questionable accuracy.

5) Supervise in a methodical manner the handling, in drying, refrigerating, and curing departments, of pork product under treatment for the destruction of live trichinae, and keep

conveniently available, at the official establishment for department use, such records as may be necessary and informative of each lot of product under treatment.

The requirements of this section to destroy possible live trichinae in the products of a kind enumerated above apply to products which are exempted from inspection.

Tapeworm (Cysticercus bovis). Carcasses of cattle showing a slight or moderate infestation ... may be passed for food after removal and condemnation of the cysts, with the surrounding tissues: Provided, That the carcass and parts, appropriately identified by retained tags, be held in cold storage at a temperature not higher than 15° F. continuously for a period of not less than 10 days: And provided further, That the boned meat from such carcasses when in boxes, tierces, or like containers, appropriately identified by retained tags, be held at a temperature of not higher than 150° F. continuously for a period of not less than 20 days. As an alternative to retention in cold storage as herein provided, such carcasses and parts may be heated throughout to a temperature of at least 140° F.

Canning with heat processing and hermetically sealed containers; cleaning containers; closure; code marking; heat processing; incubation. (a) Containers shall be cleaned thoroughly immediately before filling, and precaution must be taken to avoid soiling the inner surfaces subsequently.

(b) Containers of metal, glass, or other material shall be washed in an inverted position with running water at a temperature of at least 180° F. The container-washing equipment shall be provided with a thermometer to register the temperature of the water used for cleaning the containers.

(c) Nothing less than perfect closure is acceptable for hermetically sealed containers. Heat processing shall follow promptly after closing.

(d) Careful inspection shall be made of the containers by competent establishment employees immediately after closing, and containers which are defectively filled, defectively closed, or those showing inadequate vacuum shall not be processed until the defect has been corrected. The containers shall again be inspected by establishment employees when they have cooled sufficiently for handling after processing by heating. The contents of defective containers shall be condemned unless correction of the defect be accomplished within 6 hours following the sealing of the containers or completion of the heat processing, as the case may be, except that (1) if the defective condition be discovered during an afternoon run the cans of product may be held in coolers at a temperature not exceeding 38° F. under conditions that will promptly and effectively chill them until the following day when the defect may be corrected; (2) short vacuum or overstuffed cans of product which have not been handled in accordance with the above may be incubated under department supervision, after which the cans shall be opened and the sound product passed for food; and (3) short vacuum or overstuffed cans of product of a class permitted to be labeled, "Perishable, keep under refrigeration" and which have been kept under adequate refrigeration since processing may be opened and the sound product passed for food.

(e) Canned products shall not be passed unless after cooling to atmospheric temperature they show the external characteristics of sound cans; that is, the cans shall not be overfilled; they shall have concave sides, excepting the seam side, and all ends shall be concave; there shall be no bulging; the sides and ends shall conform to the product, and there shall be no slack or loose tin.

(f) All canned products shall be plainly and permanently marked on the containers by code or otherwise with the identity of the contents and date of canning. The code used and its meaning shall be on record in the office of the inspector in charge.

(g) Canned product must be processed at such temperature and for such period of time as will assure keeping without refrigeration under usual conditions of storage and transportation when heating is relied on for preservation, with the exception of those canned products which are processed without steam-pressure cooking by permission of the Director of Division

and labeled "perishable, keep under refrigeration".

(h) Lots of canned product shall be identified during their handling preparatory to heat processing by tagging the baskets, cages, or cans with a tag which will change color on going through the heat processing or by other effective means so as to positively preclude failure to heat process after closing.

(i) Facilities shall be provided to incubate at least representative samples of the product of fully processed canned product. The incubation shall consist of holding the canned product for at least 10 days at about 98° F.

The extent to which incubation tests shall be required depends on conditions such as the record of the establishment in conducting canning operations, the extent to which the establishment furnishes competent supervision and inspection in connection with the canning operations, the character of the equipment used, and the degree to which such equipment is maintained at maximum efficiency. Such factors shall be considered by the inspector in charge in determining the extent of incubation testing at a particular establishment.

In the event of failure by an establishment to provide suitable facilities for incubation of test samples, the inspector in charge may require holding of the entire lot under such conditions and for such period of time as may, in his discretion, be necessary to establish the stability of the product.

Preparation of dog food and similar uninspected article at official establishments; edible products department; inedible products department; denaturing. (a) When dog food or similar uninspected article is prepared in an edible product department, there shall be sufficient space allotted and adequate equipment provided so that the preparation of the uninspected article in no way interferes with the handling or preparation of products. Where necessary, separate equipment shall be provided for the uninspected article. To assure the maintenance of sanitary conditions in the edible products departments, the operations incident to the preparation of the uninspected article will be subject to the same sanitary requirements that apply to all operations in edible product departments. The preparation of the uninspected article shall be limited to those hours during which the establishment generally operates under inspectional supervision. That is, there shall be no handling, other than receiving at the establishment, of any of the meat, meat by-products, or meat food product ingredient of the uninspected article, other than during the regular hours of inspection. The material used in the preparation of the uninspected article shall not be such as would interfere with the inspection of product or the maintenance of sanitary conditions in the department. The uninspected article may be stored in, and distributed from, edible product department, provided, that adequate facilities be furnished, that there be no interference with the maintenance of sanitary conditions and that it be properly identified.

(b) When dog food or similar uninspected article is prepared in a part of an official establishment other than an edible product department, the area in which the dog food is prepared shall be separated from edible product departments in a manner similar to that required for separation between edible product departments and inedible product departments. Sufficient space must be allotted and adequate equipment provided so that the preparation of the uninspected article does not interfere with the proper functioning of the other operations at the establishment. Nothing in this paragraph shall be construed as permitting any deviation from the requirement that inedible materials, dead animals, and the like, of whatever origin, must be placed in the inedible product rendering equipment, and without undue delay. The preparation of the uninspected product must be such as not to interfere with the maintenance of general sanitary conditions on the premises, and it shall be subject to inspectional supervision similar to that exercised over inedible product departments. There shall be no return of any product to edible product departments. Trucks, barrels, and other equipment shall be cleaned before being returned in edible product departments from inedible product departments. Unoffensive material prepared outside edible product departments may be stored in, and distributed from, edible product departments only if packaged in clean, properly identified, sealed containers.

(c) Dog food or other animal food prepared, in whole or in part, from materials derived

from cattle, sheep, swine, goats, or horses, shall be distinguished from articles of human food, so as to avoid the distribution of such animal food as human food. To accomplish this, labeling of hermetically sealed, retort processed, conventional retail size containers, as, for example, "dog food" will be considered sufficient. If not in such containers, the product must not only be properly identified, but it must be of such character or so treated (denatured or decharacterized) as to be readily distinguishable from an article of human food. Dog food shall not be represented as being a human food.

Mixtures containing product but not amenable to Meat Inspection Act. Mixtures containing product but not classed as coming under the Meat Inspection Act shall not bear the inspection legend or any abbreviation or representation thereof. When such article is prepared in any part of an official establishment, the sanitation of that part of the establishment shall be supervised by Division employees and the preparation of such article shall not cause any deviation from the requirement that no uninspected products be brought into the establishment.

Contamination of product by flood water, etc.; procedure for handling. (a) Any product which has been contaminated by flood water, harbor water, or like polluted water, shall be condemned.

(b) After flood water has receded, the establishment shall, under the supervision of a Division employee, thoroughly cleanse all walls, ceilings, posts, and floors of the rooms and compartments involved, including the equipment therein. An adequate supply of hot water, under pressure, is essential for effective cleansing of the rooms and equipment. After cleansing, a solution of sodium hypochlorite containing approximately 1/2 of 1% available chlorine (5,000 parts per million), or other disinfectant approved by the Director of Division should be applied to the surface of the rooms. Where the solution has been applied to equipment which will afterwards contact meat, the equipment shall be rinsed with clean water to prevent corrosion.

(c) Hermetically sealed containers of product which have been submerged or otherwise contaminated as in paragraph (a) of this section shall be rehandled promptly under supervision of a Division employee as follows:

(1) Separate and condemn all product the containers of which show extensive rusting or corrosion, such as might materially weaken the container, as well as any swollen, leaky, or otherwise suspicious container.

(2) Remove paper labels and wash the containers in warm soapy water, using a brush where necessary to remove rust or other foreign material, immerse in a solution of sodium hypochlorite containing not less than 100 parts per million of available chlorine or other disinfectant approved specifically for this purpose by the Director of Division, and rinse in clean fresh water and dry thoroughly.

(3) After handling as in subparagraph (2) of this paragraph, the containers may be relacquered, if necessary, and then relabeled with approved labels applicable to the product therein.

(4) The identity of the canned product shall be maintained throughout all stages of the rehandling operations, to insure correct labeling of the containers.

Interstate or foreign transportation prohibited without certificate; imported articles prior to inspection excepted if handled under seals. No carrier shall transport or receive for transportation from one state or territory or the District of Columbia to another state or territory or the District of Columbia, or to any place under the jurisdiction of the United States, or to a foreign country, any article derived wholly or in part from cattle, sheep, swine, or goats unless and until a certificate be made and furnished to him in one of the forms prescribed therefor; provided, however, that any such article offered for importation into the United States may be transported and received for transportation from one state or territory or the District of Columbia, into another state or territory or the District of Columbia, without such certificate, if such product be conveyed, prior to inspection, in cars, wagons, vehicles, or pack-

ages, sealed with special import-meat seals of the Department of Agriculture or with customs or consular seals.

Eligibility of foreign countries for importation of product into the United States. (a) Whenever it shall be determined by the Secretary of Agriculture that the system of meat inspection maintained by any foreign country is the substantial equivalent of, or is as efficient as, the system established and maintained by the United States and that reliance can be placed upon certificates required under this part from authorities of such foreign country, notice of that fact will be given by including the name of such foreign country in paragraph (b) of this section, and thereafter product as to which the foreign inspection or certification is determined to be sufficient shall be eligible for importation into the United States from such foreign country, after applicable requirements of this chapter have been met. Product from foreign countries not listed in paragraph (b) of this section is not eligible for importation into the United States, except as provided for small importation for consignee's personal use.

The listing of any foreign country under this section may be withdrawn whenever it shall be determined by the Secretary of Agriculture (1) that the system of meat inspection maintained by such foreign country is not the substantial equivalent of, or is not so efficient as, the system established and maintained by the United States, or that reliance cannot be placed upon certificates required under this part from authorities of such foreign country; or (2) that, for lack of current information concerning the system of meat inspection being maintained by such foreign country or for any other reason, such foreign country should reestablish its eligibility for listing.

(b) It has been determined that product from the following foreign countries, covered by foreign meat inspection certificates of the country of origin as required by these regulations except fresh, chilled or frozen or other product ineligible for importation into the United States from countries in which the contagious and communicable disease of rinderpest or of foot-and-mouth disease exists as provided in this chapter, is eligible for importation into the United States after inspection and marking as required by the applicable provisions of this chapter.

Argentina	France	Northern Ireland
Australia	Germany (Federal	Norway
Belgium	Republic)	Panama
Brazil	Iceland	Paraguay
Canada	Ireland (Eire)	Poland
Costa Rica	Italy	Scotland
Cuba	Luxembourg	Spain
Czechoslovakia	Madagascar	Sweden
Denmark	Mexico	Switzerland
Dominican Republic	Netherlands	Uruguay
England and Wales	New Zealand	Venezuela
Finland	Nicaragua	

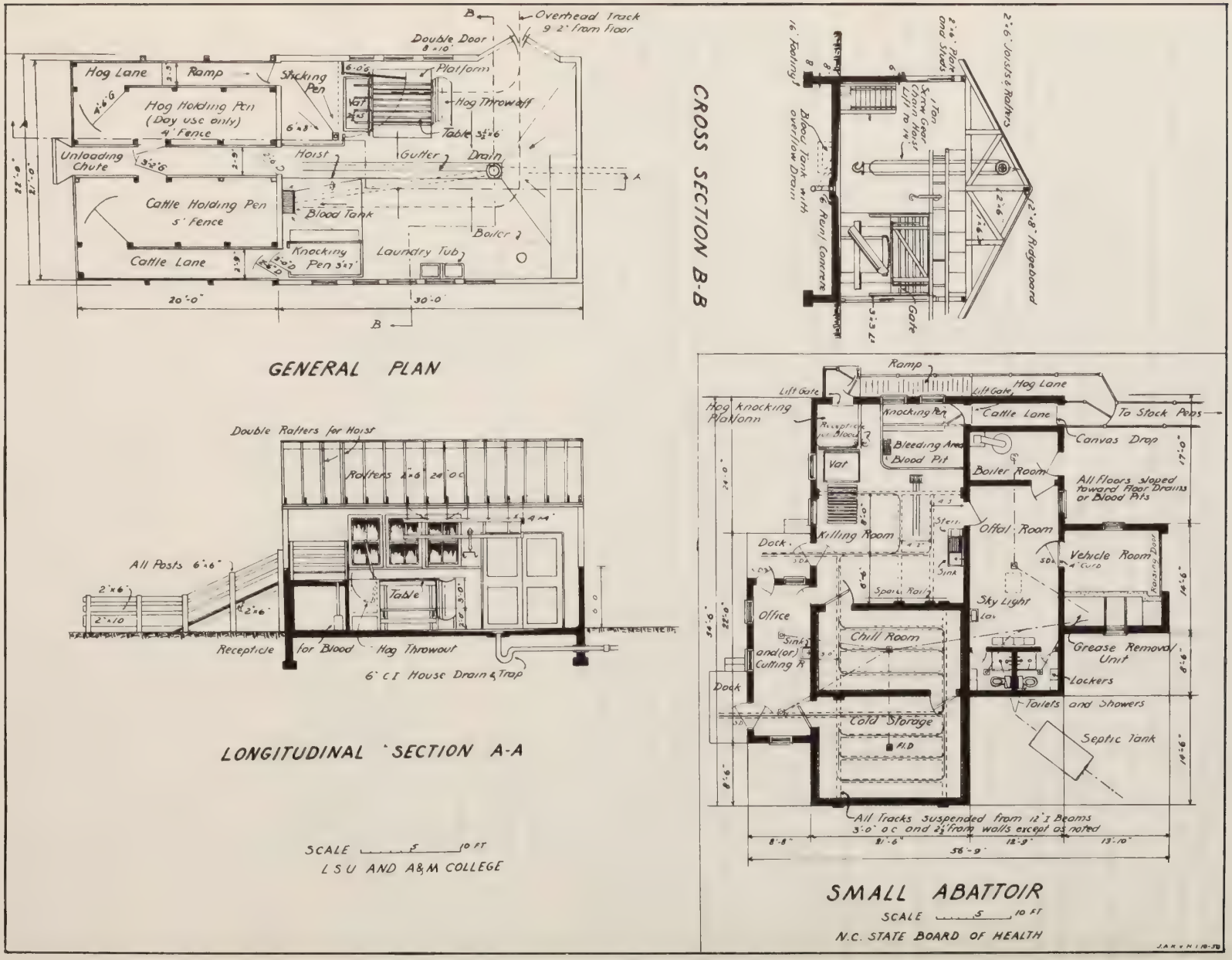

Figure 6. Farm Slaughter House

Chapter XXI

Poultry and Egg Control

The sanitary control of poultry and eggs, like that of other foods, is bound up with economic factors such as protecting the consumer's dollar by defining standards of quality of the product and encouraging or enforcing grade labelling. State laws and regulations in respect to poultry and eggs are of a mandatory character. The Sanitary Control of poultry and eggs in interstate commerce comes under the general mandatory provisions of the Federal Food, Drug, and Cosmetic Act, but the latter act does not provide a definition of standards for these food items. It provides only such provisions as will "prohibit the movement in interstate commerce of adulterated and misbranded foods." However, specific control authority in the form of poultry grading and inspection services were first authorized by the Farm Products Inspection Act of 1917. The United States Department of Agriculture developed such an inspection and certification service for grading in 1926, and it is granted to shippers and other interested parties on a voluntary basis provided they comply with the regulations set up by the Department for grading. The revised regulations of 1950 consolidated the three separate sets of regulations (i. e., poultry grading, poultry inspection, and standards and grades) into one set. This service is rendered by the payment of a fee. Although the grading of poultry and eggs in interstate commerce is voluntary, it is more and more being accepted, and is stimulating the production of better quality products, creating greater uniformity in labelling, and facilitating the process of marketing.

Such control measures are in the province of the sanitarian's work. The inspector of poultry who determines the ante-mortem and post-mortem fitness of fowl for human consumption should be a veterinarian or under the supervision of a veterinarian, while the sanitary aspects of inspection relating to environment of premises, the buildings, the equipment, and the techniques of handling and processing the poultry are the functions of the sanitarian. Sanitarians with special training and working under the supervision of veterinarians may be able to detect certain respiratory diseases among fowl by keen observation, including odors. Unhealthy birds may be detected in shipping cars by the fact that they are crowded into corners by the healthier birds, or look sick and emaciated. The process of slaughtering, dressing, chilling, freezing, packing, storing, and transporting should be sanitary and therefore understood in detail by the sanitarian. Just as poultry may transmit disease, so may eggs. The sanitarian must therefore be well informed of the nature of fresh healthy eggs and spoiled and unhealthy eggs. He must understand and supervise the process of candling, breaking, freezing, drying, packing, storing, and transporting so far as sanitation of premises, buildings, equipment, techniques, and health of personnel are concerned.

Poultry

The term poultry includes chickens, ducks, geese, turkeys, pigeons and such other domestic birds as may be used for food.

Poultry and Disease. The same kind of contamination that generally affects meat products may also affect poultry, but the latter serves as a more suitable medium for the growth of organisms in the post-mortem state than meats. How much diseased poultry may affect humans is not well known. But that they may spread such diseases as tuberculosis, typhoid, paratyphoid, ornithosis, St. Louis encephalitis, and equine encephalomyelitis is reason enough to set up controls. The latter two diseases may be spread by the chicken mite. The most common causes for rejection of fowl are: Roup (an infectious laryngotracheitis,) emaciation, dropsy, bruises, fractures, toxemia, moribund conditions, tuberculosis, fowl cholera, limberneck, decomposition, septicemia, and gape-worms. Other diseases for which fowl should be condemned are: Ornithosis, botulism, listerellosis, erysipelothrix septicemia, paratyphoid septicemia, avian leukosis, tumors, enteritis, pericarditis, salpingitis, pneumonia, pleurisy, peritonitis, arthritis, abscesses, suppurative sores and other inflammatory conditions, parasitic infestations, Newcastle disease (avian pneumoencephalitis.) Carcasses affected with the following diseases must be condemned, but when recovery occurs even though localized lesions persist, or when the lesions are of such character or extent that there is no apparent systemic disturbance, the carcass may be passed for food after removal and condemnation of the affected parts: Mycotic infections, fowl cholera, fowl typhoid, pullorum disease, infectious coryza, pseudotuberculosis,

infectious laryngotracheitis, fowl pox, trichomoniasis, enterohepatitis, coccidiosis.

Carcasses contaminated with volatile oils, paints, poisons, gases, or other substances which affect their wholesomeness, those showing evidence of having died from other causes than slaughter, and those having been overscalded should be condemned.

Condemned Carcasses should be disposed of by:
Steam Sterilization in a pressure tank under at least 40 lbs. of pressure maintained for a sufficient time to effectively destroy the material for food purposes.

Incineration or complete destruction by burning.

Chemical Denaturing with crude carbolic acid, kerosene or fuel oil, or any phenolic disinfectant conforming to commercial standards, such as CS 70-41 or CS 71-41, which shall be used in at least 2% emulsion or solution.

Inspection of Poultry. Inspection concerns itself with the following phases:
1) The healthiness of the live birds or the carcasses.
2) The weight of the crops by manual estimation to prevent deception.
3) The examination of feed for presence of prohibited materials such as sand or gravel.
4) The technique of slaughtering, dressing, and processing such as curing and freezing.
5) The sanitary facilities and conditions of keeping the live birds and processing the slaughtered animals.
6) The inspection of labelling and advertising in accordance with correct standards of identification.

Birds which appear to be sick or emaciated and unfit for human consumption should be removed from cages and destroyed. If the diseased birds be in railroad cars or trucks, these should be disinfected before other birds are transported in them.

After slaughtering, the birds should be bled well in order to increase their keeping quality. Dressing begins by scalding the bird in water at 160° to 170° F. long enough to facilitate rubbing the feathers off easily and then immediately immersing the carcass in clean, cold running water for 3 or 4 hours. In this way, the skin absorbs some moisture and becomes plumper and yellower, but dry scaly patches often develop on the skin soon after storing. This wet method is therefore objectionable, and the dry method of cooling by cold air or refrigeration is better. The semi-scald method of dressing consists of dipping the bird in water at 125° to 130° F. for 1/2 minute, then picking instead of rubbing the feathers off. This method increases the keeping qualities of the carcass almost as well as in dry picking. After picking the feathers the bird is immediately hung in a cooler and chilled to about 32° F. for around 24 hours. In wax or rosin plucking, the carcass is coated with hot wax or rosin and then stripped off in sheets, taking the feathers and the pin feathers off in the process.

The next step is the post-mortem inspection. This consists of cutting the skin between the legs and abdomen and allowing the legs to be broken down so the bird may set firmly on the inspection pan. A circular incision is made in the abdomen, allowing the inspector to raise the breast forcibly, to break the back, and to expose the internal organs. The carcasses are placed on a moving table or belt which carries them past the inspector. Unfit carcasses are placed in condemnation cans for denaturing. Good stock is passed to the chopping block where the head and feet are removed, then to the evisceration section (if this step be desired), and finally to the washer. The giblets are cleaned and replaced in the body cavity. Contamination of the abdominal cavity in the process of evisceration may reduce the keeping quality of the birds, but improved cold-storage techniques have eliminated this deteriorating hazard.

Poultry may be packed in boxes or barrels. The one layer box is the best. Wet-chilled birds are generally packed in ice in barrels. Dry-chilled birds are packed in boxes without ice. It is a practice to line the poultry boxes with parchment or wax paper and to subject the boxed poultry to an initial freezing at 10° F. or lower. For cold storage, poultry is quickly frozen at a temperature of -5° F. for 48 hours, and held at about 0° F. Freezing gives best results when birds

are killed by the sticking-debraining method, then dry picked, and dry cooled. The low humidity of storage rooms gradually absorbs the moisture of the poultry and causes dry scaly spots on the skin known as "freeze burn" or "scald spot."

The boxes are stacked close together to reduce evaporation. For consumption, the dealer may thaw the frozen poultry by immersing in running cold water for 10 hours. This improves the appearance of the skin but reduces the keeping quality; it also removes some flavor and slightly increases the weight. A better procedure is to hang the frozen stock overnight in the refrigerator until the birds are defrosted, and then to sell them from refrigerated show-cases. It is better for the defrosting to be done by the housewife just before she is ready to use the poultry.

Turkey flesh bruises easily from rough handling while the bird is alive. Before killing the crops should contain no food, but plenty of water should be fed. The carcasses should be dry-picked immediately after killing and while still bleeding. After cleaning, the torn skin should be sewed with needle and thread to prevent bacterial invasion of the flesh. They should be cooled immediately to 34° F. within 24 to 36 hours, then graded and packed in barrels or boxes lined with parchment paper.

Changes in poultry which take place in weeks in the chill room are about equal to those changes which take place in a house refrigerator in 5 to 7 days. For fairly long distant shipping, refrigerated cars at 31° F. or below should be used. Poultry can be stored in cold storage for as long as 9 months without apparent loss of flavor, if, when used, the carcasses be properly thawed. Well prepared fowl may last for a year in storage without being detrimental to health. Decomposition starts first around the bones which become dark. The process of decomposition of the flesh is the same as that for other types of meat. Frozen poultry deteriorates more slowly in 12 months than freshly dressed poultry in a housewife's ice-box in 2 days.

Bacteria and molds do not readily penetrate tissues during storage. As the storage temperature approaches 32° F., bacteria become fewer. Poultry stored at temperatures of 5 to -14° F. undergo practically no bacterial spoilage. These temperatures destroy many bacteria except the more resistant species. Cold storage fowl contain much more bacteria in their flesh than fresh fowl. The predominant skin bacteria are of the genera Micrococcus, Flavobacterium, and Achromobacter. Psychrophiles may grow on the skin of chickens at 32° F. to produce odor after four weeks, and at 30° F., after 6 weeks. Thawing allows bacteria to grow. Bacterial decomposition after removal from refrigerator is greatest for frozen poultry, least for freshly killed poultry, and intermediate for chilled poultry. Slime formation on poultry is delayed by addition of sodium hypochlorite to storage tanks and by dipping the dressed fowl in a saturated salt brine. Drawn chickens placed in cold storage show many more bacteria than undrawn. However, sanitary methods of drawing may yield very good keeping qualities as compared to undrawn fowl.

Federal Poultry Grading and Inspection Regulations, Standards, and Grades

In 1951, the Federal-State service phase of the Federal poultry inspection and grading service was instituted. Such service was furnished in any State in which the cooperating State agency made a request and became a party to a cooperative agreement. In 1957, a new phase in poultry inspection was introduced by an Act of Congress, called the Poultry Products Inspection Act, providing for compulsory inspection of poultry by the U.S. Dept. of Agriculture. This act provides for the inspection of poultry and poultry products by the inspection service of the U.S. Dept. of Agriculture to prevent the movement in interstate or foreign commerce or in a "designated" major consuming area in the country of poultry products which are unwholesome, unadulterated, or otherwise unfit for human food. A "designated" major consuming area is prescribed upon application of state or local agency or local industry group to the Secretary of the U.S. Dept. of Agriculture after public hearings to determine need. The Act provides for anti-mortem and post-mortem inspection, reinspection, and quarantine; sanitation, facilities and practices; labeling; prohibited acts; complete coverage of official establishments; records of interstate shipment; penalties; reporting of violations; exemptions; imports; course of inspections; separability of provisions; and effective date. The minimum standards for sanitation, facilities, and operating procedure is very similar to the U.S. Public Health Service Poultry Ordinance of 1955. Therefore, the latter ordinance will be given below instead of the regulations of the U.S. Department of Agriculture. However, the standards and grades will be those of the U.S. Department of Agriculture.

Poultry Ordinance, 1955 Edition - U.S. Public Health Service

(In order to obviate repetition of sanitary provisions generally found in other sanitary ordinances, repetitious materials have been omitted from some sections. The text in parenthesis is used to explain the content of omitted provisions, or are condensations of wording of items that could be expressed more succinctly.)

An ordinance defining poultry and poultry products, dressed poultry, eviscerated poultry, inspector, and official inspection mark; requiring permits for the processing of poultry and poultry products; prohibiting the sale of adulterated or misbranded poultry and poultry products; providing for the enforcement of this Ordinance, including the inspection of records and of private and public property; requiring official inspection for wholesomeness of live poultry and of poultry and poultry products; regulating the sanitary operation of poultry-processing establishments, the inspection of live poultry and of poultry and poultry products, and the labeling, processing, storage, transportation, and sale of poultry and poultry products; and providing for the fixing of penalties.

Be it ordained by the _____ of the Municipality of _____ (1) as follows:

Section 1. Definitions

For the purposes of this Ordinance, the following words and phrases shall have the meanings ascribed to them in this section:

(a) Adulterated: Poultry and poultry products shall be deemed to be adulterated:

1. If they bear or contain any poisonous or deleterious substance which may render them injurious to health; but in case the substance is not an added substance, such poultry and poultry products shall not be considered adulterated under this clause if the quantity of such substance in such poultry and poultry products does not ordinarily render them injurious to health.

2. If they bear or contain any added poisonous or added deleterious substance, unless such substance is necessary in their production or unavoidable under good manufacturing practices and unless there are other provisions of law limiting the quantity of such added substance on or in such poultry and poultry products: Provided, That any quantity of such added substance exceeding the limits so fixed shall also be deemed to constitute adulteration.

3. If they consist in whole or in part of any filthy, putrid, or decomposed substance or if they are otherwise unfit for food.

4. If they have been processed, prepared, packed or held under unsanitary conditions, whereby they may have become contaminated with filth, or whereby they may have been rendered injurious to health.

5. If they are, in whole or in part, the product of diseased poultry or of poultry which has died otherwise than by slaughter.

6. If their container is composed, in whole or in part, of any poisonous or deleterious substance which may render the contents injurious to health.

7. If any substance has been substituted, wholly or in part, therefor.

8. If damage or inferiority has been concealed in any manner.

9. If any substance has been added thereto or mixed therewith which makes them appear better or of greater value than they are.

(b) Carcass: Any poultry carcass.

(c) Class: Any subdivision of a product based on essential physical characteristics that differentiate between major groups of the same kind or between species.

(d) Denatured: Subjected to the application of crude oil, kerosene, or other material or procedure, so as to preclude use for human consumption.

(e) Dressed Poultry: Poultry which has been slaughtered for human food, with the head, feet, and viscera intact, and from which the blood and feathers have been removed.

(f) Employee: Any person who is employed in a poultry-processing establishment, and who handles poultry or poultry products, processing equipment, utensils, containers, or packaging materials.

(g) Eviscerated Poultry, or Ready-to-Cook Poultry: Dressed poultry from which the protruding pinfeathers, vestigial feathers (hair or down as the case may be), head, shanks, crop, oil gland, trachea, esophagus, entrails, reproductive organs and lungs have been removed, and

1. Substitute proper legal jurisdiction here and in all similar places throughout the Ordinance.

which, with or without the giblets, is ready for cooking without need of further processing or cleaning.

(h) Feeding or Holding Station: Any room or area of a poultry-processing establishment in which live poultry is fed or held prior to slaughter.

(i) Flood-Level Rim: The top edge of a fixture or receptacle from which the water overflows.

(j) Giblets: Livers from which the bile sacs have been removed, hearts from which the pericardial sacs have been removed, and gizzards from which the linings and contents have been been removed: Provided, That giblets shall mean one of each of these organs when referring to one eviscerated carcass "with giblets."

(k) Health Authority:(2) The health authority of the Municipality of _____, or an authorized representative thereof.

(l) Inspector: Any duly qualified employee of the Municipality of _____ who is authorized by the health authority to inspect live poultry or poultry and poultry products and to perform other official duties related to the carrying out of the provisions of this Ordinance.

(m) Inspector-in-Charge: The veterinary inspector assigned to a poultry-processing establishment to perform or effectively to supervise the inspection of live poultry and of poultry and poultry products, and for related official activities, in such establishment.

(n) Inspector-Veterinary: An inspector who is a duly qualified veterinarian.

(o) Misbranding: The use of any written, printed, or graphic matter upon or accompanying poultry or poultry products or containers thereof, including signs or placards displayed in relation to poultry or poultry products offered for sale, which is false or misleading in any particular, or which violates any of the provisions of Section 5 of this Ordinance.

(p) Official Inspection Mark: Official device or insignia of the health authority, or of any other poultry-inspection authority of Federal, State or local government which enforces provisions substantially equivalent to the requirements of this Ordinance, certifying poultry as to fitness for use as human food, which is applied to poultry or poultry products, or upon or within the containers thereof.

(q) Person: Any individual, partnership, corporation, company, firm, institution, trustee, association, this political subdivision, or other public or private entity.

(r) Poultry-Processing Establishment: Any establishment in which any processing operation, as defined by paragraph (t) of this section, is conducted.

2. In jurisdictions where the authority for the enforcement of this Ordinance is vested in an agency other than the health department, the proper authority should be substituted for the term "health authority" wherever the term appears in this Ordinance.

(t) Processing: Any operation or combination of operations whereby poultry which is intended for sale for human consumption is killed, dressed, eviscerated, cut-up, heat-treated, canned, packed, repacked, reprocessed, or changed in size, shape or form, for marketing for human consumption: Provided, That this definition shall not include the further preparation of ready-to-cook or precooked poultry or poultry products by a retail establishment where the resulting poultry or poultry product so prepared is subsequently sold only at retail on the premises of such establishment where such further preparation is conducted.

(u) Processing Room or Area: Any room or area in which processing is conducted.

(v) Smooth: The term "smooth," used with reference to walls, partitions, and posts, shall mean a surface which is at least as smooth as steel-troweled cement-plaster finish. When used with reference to floors, the term "smooth" shall mean a surface which is approximately as smooth as concrete with a wood-float finish.

Section 2. Permits

It shall be unlawful for any person to operate a poultry-processing establishment within the Municipality of _____ or its police jurisdiction who does not possess a permit from the health authority. Only a person who complies with the provisions of this Ordinance shall be entitled to receive and retain such a permit.

The operator shall apply to the health authority for such a permit. The health authority shall inspect such poultry-processing establishment within 5 days after the filing of such application, and a permit shall be issued by the health authority only after compliance by the operator with the applicable provisions of this Ordinance. (Other provisions: Conspicuous dis-

play of permit; not transferable permit; notifying health authority within 24 hours of disposing of plant and identifying the person taking plant over; temporary suspension of permit to violations, interference with health authority duties; granting of hearing if permit be denied.)

Section 3. Approval of Plans

Poultry-processing establishments which are hereafter constructed, reconstructed, or extensively altered (including major structural changes or alterations of principal fixed equipment) in the Municipality of _____ or its police jurisdiction shall conform in their construction to the requirements of this Ordinance. Properly prepared plans and specifications shall be submitted to the health authority for approval, and signed approval shall be obtained from the health authority before work is begun.

Section 4. The Sale or Possession of Adulterated or Misbranded Poultry of Poultry Products Prohibited.

(Same as for milk or other foods).

Section 5. Labeling and Identification

Poultry and poultry products which have been inspected and passed by the health authority shall be marked with the official inspection mark of the health authority in accordance with the provisions of Section 8 (k) of this Ordinance. All other poultry and poultry products shall be marked in a similar manner with the official inspection mark of the Federal, State, or local poultry-inspection authority which shall have inspected and passed such poultry and poultry products. Each shipping container of poultry and poultry products delivered or transported on a wholesale basis shall bear in distinctly legible form the identification of the contents, and the name and address of the processor or distributor.

Nothing within this Section shall be deemed to authorize or excuse non-compliance with the applicable Federal or State laws or regulations pertaining to the branding, labeling, or other identification of foods.

Section 6. Inspection; Records.

The health authority, after proper identification, shall be permitted to enter upon private or public property within the Municipality of _____ or its police jurisdiction where poultry or poultry products are processed, stored, transported, or offered for sale, at any reasonable time, for the purpose of inspecting and investigating conditions relating to the enforcement of the provisions of this Ordinance.

Prior to the issuance of a permit, and at least once each month thereafter during periods when poultry-processing operations can be observed, the health authority shall inspect[3] each poultry-processing establishment to determine compliance with the provisions of this Ordinance. The health authority shall also make such other inspections and investigations as are necessary for the enforcement of this Ordinance. A report of each such inspection or investigation shall be prepared, one copy of which shall be furnished to the person in charge of the establishment concerned (or, if no establishment is concerned, to the person responsible for the violation), and another copy shall be filed in the office of the health authority.

Records of each transaction of receipt and distribution of poultry and poultry products on a wholesale basis shall be prepared and kept on file for a period of 12 months by poultry-processing, storage, and sales establishments. Such records shall be available for examination in such establishments by the health authority during normal business hours.

It shall be unlawful for any person who, in an official capacity, obtains any information under the provisions of this Ordinance concerning any method or process which as a trade secret is entitled to protection, to use such information to his own advantage or reveal it to anyone other than the health authority, or the courts when relevant in any judicial proceeding under this Ordinance.

Section 7. Enforcement; Service of Notices; Hearings; Orders

Whenever the health authority discovers a violation of any provision of this Ordinance, he shall notify the person responsible for the violation. Such notice shall:

(1) Describe the condition found and state which section of this Ordinance is violated by such condition;

(2) Provide a reasonable period of time for the correction of the violation;

(3) State that, unless the condition described is corrected within the specified period of time, any permit issued under the provisions of this Ordinance may be suspended or revoked, or court action may be initiated;

(4) State that an opportunity for appeal will be provided, if a written request for a hearing is filed with the health authority within 10 days of receipt of the notice.

Such notice shall be deemed to have been properly served when a copy of the inspection or investigation report [4] required by Section 6 of this Ordinance, containing the information outlined above, has been delivered personally to the owner, operator, or person in charge of the establishment concerned at the time of the inspection or investigation, or, if no establishment is concerned, to the person responsible for the violation; or when a copy thereof is sent by registered mail to the last known address of such person.

Any person affected by such notice may request, and shall be granted, an opportunity for a hearing on the matter before the health authority: [5] Provided, That such person shall file in the office of the health authority, within 10 days after the notice was served, a written petition requesting such hearing and setting forth a brief statement of the grounds therefor. Upon receipt of such petition, the health authority shall set a time and place for such hearing, and shall give the petitioner written notice thereof.

3. Sample copies of a poultry-processing establishment inspection form based on the requirements of this Ordinance may be obtained, upon request, from the Public Health Service. This form will be available for purchase direct from the Supt. of Documents, Government printing Office, Washington 25, D.C.

4. See footnote 3.

5. The hearing should be held, if possible, before an official or body other than the officer making the initial determination of noncompliance.

The hearing shall be commenced not later than 7 days after the day on which the petition was filed: Provided, That, upon application of the petitioner, the health authority may postpone the date of the hearing for a reasonable time beyond such 7-day period, if, in his judgment, the petitioner shall have submitted a good and sufficient reason for such postponement. Based upon the findings of such hearing, the health authority shall sustain, modify, or withdraw the notice, or initiate such enforcement action as he may deem necessary. A copy of the findings and decision of the health authority shall be furnished to the person who requested the hearing.

When, after a hearing, the health authority sustains or modifies a notice, or if a written petition for a hearing has not been filed in the office of the health authority within 10 days after a notice has been served, the health authority may issue an order suspending or revoking any permit issued under the provisions of this Ordinance to any poultry-processing establishment concerned, or court action may be initiated, if a re-inspection indicates that corrective action has not been completed within the time specified in the notice; Provided, That, if a hearing has been held and the findings of such hearing justify such modification of the notice, the health authority may extend the period of time within which corrective action is to be completed.

Notwithstanding the other provisions of this Ordinance, whenever the health authority finds grossly unsanitary conditions in a poultry-processing establishment or any area thereof, or whenever he finds that substantial quantities of poultry or poultry products which are unfit for food are being processed, or whenever he finds any other condition which involves a substantial hazard to the public health, he may, without notice or hearing, issue a written order citing the existence of such condition and directing that corrective action be taken, including, if deemed necessary, stoppage of operations in the affected area. Such order shall be effective immediately or within a period specified in the order. Any person to whom such order is directed shall comply therewith, but, upon petition to the health authority, shall be afforded a hearing as soon as possible, but in any case not later than 4 days after the petition was filed.

After such hearing, depending upon his finding as to compliance or noncompliance with the provisions of this Ordinance, the health authority shall continue such order in effect, or modify it, or revoke it.

Any person aggrieved by a decision of the health authority may seek relief therefrom in any court of competent jurisdiction, as provided by the laws of this State.

Section 8. Inspection and Examination of, and Hold Orders on, Poultry and Poultry Products, Equipment and Packaging Material: Condemnation of Poultry and Poultry Products.

(a) Inspection for Wholesomeness Required. All live poultry about to be slaughtered for processing, and all poultry and poultry products processed within the Municipality of _____ or its police jurisdiction, shall be inspected for wholesomeness in accordance with the provisions of this Section. Such inspection shall be performed by, or under the direct supervision of a duly qualified veterinarian.

(b) Prohibitions.

(1) It shall be unlawful for any person to process poultry or poultry products within the Municipality of _____ or its police jurisdiction except under the supervision of the health authority, who shall inspect such poultry and poultry products for wholesomeness, unless such processing is done under the supervision of a Federal or State poultry-inspection authority enforcing provisions substantially equivalent to the requirements of this Ordinance.

(2) It shall be unlawful for any person within the Municipality of _____, or its police jurisdiction, to sell, offer, or expose for sale, or to have in possession with intent to sell, or to process further or have in possession with intent to process further, any poultry or poultry products which are not adequately identified as having been inspected and passed by the health authority, or by a Federal, State, or local poultry-inspection authority enforcing provisions which are substantially equivalent to the requirements of this Ordinance.

(3) It shall be unlawful for any person within the Municipality of _____ or its police jurisdiction to receive for further processing any poultry or poultry products in a poultry-processing establishment operating under the supervision of the health authority, unless an inspector assigned to such establishment shall be informed of the arrival of such poultry or poultry products and shall examine the identification thereof. Such poultry or poultry products shall be subject to the provisions of this Ordinance.

(c) Inspection Facilities. Each person operating a poultry-processing establishment under the supervision of the health authority shall provide rentfree, such facilities and assistance as may be found necessary to permit the inspector to inspect poultry and poultry products efficiently, in accordance with the provisions of this Ordinance. Each poultry-processing establishment which conducts processing operations on an average of more than 1 working day per week shall provide facilities which shall include, but shall not be limited to:

(1) Furnished office space, including light, heat, and janitor service, for official purposes. The space set aside for this purpose shall be conveniently located, properly ventilated, and provided with lockers or cabinets suitable for the protection and storage of supplies and with facilities suitable for inspectors to change clothing.

(2) Refrigerated facilities in which carcasses or parts thereof may be held for further inspection, in such numbers and such locations as the needs of the inspection in the plant may require. Such facilities shall be capable of being suitably sealed, to prevent the entry of unauthorized persons. The entry of such facilities by any person under conditions or at times not authorized by the health authority shall be unlawful.

(d) Time Schedules; Presence of Inspector.

(1) Each person operating a poultry-processing establishment under the supervision of the health authority shall submit to the health authority, and receive approval of, a regular time schedule for processing operations. The health authority may require operations to be conducted during reasonable hours. Reasonable notice shall be given by a poultry-processing establishment to the health authority if it is desired to conduct processing operations at times other than in accordance with the approved, regular time schedule.

(2) An inspector shall be on duty in such establishment during all periods when processing operations of any kind are conducted, and the starting or continuing of any processing operation when no inspector is present shall be unlawful. The owner or operator of each such poultry-processing establishment shall inform the health authority in advance regarding all poultry-processing operations to be conducted, and shall conduct such operations

only at such time and in such manner as the health authority may prescribe, to assure clean handling of food and to afford opportunity for inspection, in accordance with the provisions of this Ordinance.

(e) Access to Establishment; Inspector's Tags, Devices, and Methods of Identification for Holding.

(1) For the purpose of any examination or inspection necessary to enforce any of the provisions of this Ordinance, inspectors shall be permitted to have access at all times, by day or night, whether the establishment is in operation or not, to every part of any establishment to which they are assigned for duty by the health authority.

(2) An inspector may use such tags, devices, and methods as may be approved by the health authority for the identification of poultry and poultry products which are held for further examination and all equipment, utensils, or packing materials which are to be held for proper cleaning or disposal.

(f) Daily Report of Inspection. Each Inspector-in-Charge shall submit a signed daily report of inspection from each poultry-processing establishment to which he is assigned. The original of each such report shall be filed in the office of the health authority. The report shall show the total pounds of poultry or poultry products inspected; the total pounds passed after inspection; and the number, class, and poundage of poultry or poultry products condemned and the reasons for such condemnation.

When an inspector observes a violation of any provision of this Ordinance which is not promptly corrected, or which is of a recurrent or continuing nature, the Inspector-in-Charge shall include a report of inspection for the establishment concerned, and the health authority shall notify the person responsible for the violation, in accordance with the provisions of Section 7 of this Ordinance.

(g) Ante-Mortem Inspection. The health authority shall require to be made, by an inspector, such ante-mortem inspection of all lots of poultry about to be slaughtered as he shall deem necessary to assure proper disposition of sick and suspect poultry. No poultry shall be slaughtered for processing without such ante-mortem inspection as may be required to comply with the provisions of this subsection. If necessary in order to determine proper disposition, poultry which do not appear to be entirely normal shall be removed from the battery, coop, or pen for closer examination.

(1) Conditions Necessitating Condemnation. Poultry which obviously show a condition that would cause condemnation of their carcasses on post-mortem inspection, shall be condemned and promptly disposed of in accordance with the provisions of subsection (i) of this Section.

(2) Conditions Necessitating Segregation as Suspects for Separate Slaughter. Poultry which do not exhibit ante-mortem signs justifying condemnation without post-mortem examination, but which are suspected of being diseased, either on the basis of their appearance or because of information available regarding the history of the flock, shall be identified as suspects, segregated, and slaughtered, dressed, eviscerated, and subjected to post-mortem inspection separately from other poultry. All equipment used in the processing of suspect poultry shall be thoroughly washed, rinsed, and subjected to a bactericidal treatment approved by the health authority before being used again for the processing of apparently healthy poultry.

(3) High Rate of Infection; Suspect Lots. When, however, upon ante-mortem inspection, a lot of live poultry is found to contain a relatively large number of sick birds, or when a large percentage of the lot is suspected of being infected, if it is practicable to do so if conditions warrant, the health authority may authorize such a lot of poultry, in whole or in part, to be removed from the processing establishment for observation or treatment under the supervision of the State Livestock sanitary authority. Whatever additional precautions are deemed necessary by the health authority shall be taken to prevent the spread of disease. Batteries used for such sick or suspect lots of poultry shall be cleaned and disinfected before being used again.

(h) Post-Mortem Inspection.

(1) A post-mortem inspection of each carcass shall be performed by an inspector at the time of evisceration. This inspection shall include a complete visual examination of the viscera and of the exterior and interior of the carcass, and shall also include palpation and other procedures considered necessary by the inspector for proper identification and evaluation

of disease processes, tissue changes, or other conditions which may affect the fitness of the poultry for use as human food.

(2) No viscera or any part thereof shall be removed from any dressed poultry except at the time of evisceration and post-mortem inspection.

(3) Each carcass shall be opened so as to expose the organs and the body cavity for proper examination by the inspector and, if passed, shall be prepared immediately after inspection as eviscerated poultry.

(4) Poultry and poultry products in which there is no evidence of disease or other condition rendering such poultry or poultry products unfit for use as human food, and which comply with all applicable provisions of this Ordinance, shall be passed and labeled with the official inspection mark of the health authority as provided by (k) of this Section.

(5) If, at the time of post-mortem inspection, any poultry shows evidence of disease or other condition which renders such poultry, or any portion thereof, unfit for use as human food, such poultry or such unfit portion thereof shall be condemned and disposed of in accordance with the provisions of subsection (i) of this Section. A carcass, including all parts thereof, shall be condemned if affected with any disease hazardous to human health; if showing evidence of general systemic disturbance, e.g., septicemia, toxemia, emaciation; if affected with any localized condition so extensive or of such nature as to have a generalized systemic effect; or if affected by any other condition so extensive or repulsive as to render the carcass unacceptable to the consumer. If an abnormal condition is confined to a small part of the carcass, or to particular organs, and is not of such nature as to warrant condemnation of the whole carcass, all affected parts shall be removed in a sanitary manner and condemned; any part of the carcass which is contaminated by dangerous, purulent, or obnoxious material during the removal of such affected parts shall likewise be removed and condemned.

(6) Each carcass, including all parts thereof, or any other poultry or poultry products, concerning which a final decision cannot be made on first examination by the inspector, shall be held for further examination. Proper identity shall be maintained until a final examination has been completed.

(i) Disposition of Condemned Poultry and Poultry Products, Including Live Poultry. All poultry condemned on ante-mortem inspection shall be slaughtered and the carcasses of such poultry, and all other poultry and poultry products condemned in accordance with the provisions of this Ordinance, shall be denatured or destroyed, under the supervision of an inspector, in a manner approved by the health authority, so as to prevent use for human food and preclude dissemination of disease through consumption by animals. Notwithstanding other provisions of this Ordinance, such carcasses and such poultry and poultry products condemned under the preceding provisions of this Section shall be so denatured or destroyed on the same day condemned, unless an appeal from the inspector's action is made prior to such disposition, in accordance with the provisions of subsection (m) of this Section.

(j) Inspected Poultry Certificates. If requested, inspection certificates approved by the health authority as to form, shall be prepared and signed by a veterinary inspector on lots of poultry or poultry products which are inspected by the health authority. Such certificate shall show:

(1) The class (or classes) and quantity of poultry or poultry products covered by such certificate;

(2) That such poultry or poultry products were processed under sanitary conditions in a poultry-processing establishment holding a permit from the health authority; and

(3) Pertinent information concerning the amount of such poultry or poultry products certified as wholesome and, if requested, the amount from the original lot that was condemned on ante-mortem or post-mortem inspection.

(k) Marking of Inspected Products.

(1) When poultry or poultry products which have been inspected for wholesomeness and passed by the health authority are placed or packed in any container in any poultry-processing establishment within the Municipality of _____ or its police jurisdiction, the official inspection mark shall be placed on the label of the container. If the label is printed or otherwise applied directly to the container, the principal display panel of the container shall, for this purpose, be considered as the label.

(2) Any label or packaging material which bears the official inspection mark of the health authority shall be used only for poultry or poultry products which are determined to be fit for use as human food and in compliance with all applicable provisions of this Ordinance through inspection thereof by the health authority.

(3) No label or packaging material bearing the official inspection mark of the health

Table 1. Types of Materials of Which Various Equipment, Utensils, and Facilities should be Constructed

Equipment, utensils, and facilities	Iron	Rubber	Concrete	Stainless steel and monel metal	Aluminum	Galvanized iron	Copper (tin plated)	Porcelain or glazed tile
Batteries	---	---	---	A	A	A	---	---
Overhead conveyors	A	---	---	A	---	A	---	---
Conveyor track	A	---	---	A	---	A	---	---
Shackle chain	---	---	---	A	---	A	---	---
Shackles	---	---	---	A	---	A	---	---
Blood trough	A	---	A	A	A	A	---	---
Scalding vat	A	---	---	A	---	A	---	---
Mechanical pickers	A	A	---	A	A	A	---	---
Mechanical scrubber	A	A	---	A	A	A	---	---
Wax dipping tank	A	---	---	A	A	A	---	---
Trough for catching wax	A	---	---	A	A	A	---	---
Water-spray cooling chamber	---	---	---	A	A	A	---	---
Opening trough	---	---	---	A	A	A	---	---
Eviscerating pans	---	---	---	A	A	A	---	---
Inspection table (those parts which come in contact with product	---	---	---	A	A	A	---	---
Eviscerating trough	---	---	---	A	A	A	---	---
Framework (of equipment)	A	---	---	A	---	A	---	---
Inside and outside washer	---	A	---	A	A	A	---	A
Gizzard, heart and liver trimming tables	---	---	---	A	A	A	---	---
Defrosting trucks	---	---	---	A	A	A	---	---
Defrosting tanks	---	---	A	A	---	A	---	A
Cooling racks	---	---	---	A	A	A	---	---
Tanks or vats and other equipment used for cooling products	---	---	A	A	A	A	---	---
Above-the-floor grease traps	---	---	---	A	A	A	---	---
Utensils for handling edible products	---	---	---	A	A	A	---	---
Boning and cooling tables, cutting surfaces	---	---	---	A	A	A	---	---
Cooking kettles	A	---	---	A	A	A	A	---

authority may be used unless a finished copy, sample, or photostat of such label or packaging material has been approved by the health authority and is on file in the office of the health authority and in the records of the inspector-in-charge of the poultry-processing establishment concerned.

(4) The official inspection mark to be used with respect to poultry and poultry products inspected within the Municipality of _____ or its police jurisdiction shall include:

"Inspected and Passed (Jurisdiction, and code number identifying plant)." Such official inspection mark shall be distinctive and bear no resemblance to the Federal poultry inspection mark of the U.S. Department of Agriculture.

(5) Neither the official inspection mark nor any copy or facsimile thereof shall be applied on dressed poultry or any other poultry or poultry products which have not been in-

Table 2. Summary of United States Standards for Quality of Live Poultry, 1953
(Individual Birds)

Quality Factors	A Quality or No. 1 Quality	B Quality or No. 2 Quality	C Quality or No. 3 Quality
Health and Vigor	Alert, bright eyes, good health, vigorous.	Good health, vigorous.	Lacking vigor, but healthy
Feathering	Well feathered, lusterous, may be slight scattering of pinfeathers.	Fairly well feathered, moderate amount of pinfeathers.	Large number of pinfeathers, complete lack of plumage on back.
Conformation	May have slight deformity of breastbone, or curvature of back.	May have slightly crooked breastbone, moderately crooked back, slightly misshapen wings or legs.	Crooked breastbone, hunch back, slight crippling, and other deformities.
Fleshing	Well developed, broad, long, well fleshed breast. Thighs and back well fleshed.	Fairly well fleshed.	Poorly developed, narrow breast, poorly fleshed.
Fat Covering	Breast, back, hips, pin bones well covered; hens, stewing chickens, or fowl may not have excessive abdominal fat.	Good coverage on breast and legs; hens, stewing chickens, or fowl may have excessive abdominal fat.	Small amount in feather tracts; completely lacking on back and thighs.
Defects	No tears nor broken bones; may have slight scratches, skin bruises, callouses, or scaly shanks.	No tears, broken bones, severe breast blisters, nor heavy callouses; may have moderate skin bruises and slight flesh bruises, moderate scaly shanks.	Has skin bruises, moderate flesh bruises, severe breast blisters; no broken bones nor tears, seriously scaly shanks.

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spected and passed by the health authority, or on the labels or containers of such poultry or poultry products.

(6) The official inspection mark shall not be affixed to or placed on, or be caused to be affixed to or placed on, any poultry or poultry products or container thereof except by an inspector or under the supervision of an inspector. Inspectors shall have supervision over the use and handling of all material bearing official inspection marks.

(l) Removal of Official Inspection Marks. Any person operating a poultry-processing establishment within the Municipality of _____ or its police jurisdiction, and who receives into such an establishment poultry or poultry products in containers which bear any official inspection marks of this or any other jurisdiction, shall destroy or deface such official inspection marks upon removal of such poultry or poultry products from the containers.

(m) Appeals from Inspector's Actions. Any appeal from a decision of an inspector shall be made to his immediate superior having jurisdiction over the subject matter of the appeal.

(n) Examination of, and Hold Orders on, Poultry and Poultry Products, Equipment, and Packaging Material. Poultry and poultry products processed, stored or offered for sale within the Municipality of _____ or its police jurisdiction may be examined by the health authority for the detection of misbranding or adulteration. Pending further disposition, the health authority may, by giving written notice, place a hold order on any poultry or poultry products he determines or has probable cause to believe to be misbranded or adulterated: Provided, That no hold order shall be issued if, with the concurrence of the health authority, such poultry or poultry products are immediately denatured or destroyed.

Under a hold order, poultry or poultry products shall be permitted to be suitably stored, and neither such poultry or poultry products nor the containers thereof shall be relabeled, repacked, reprocessed, altered, disposed of, or destroyed without permission of the health authority, except on order by a court of competent jurisdiction: Provided, That the hold order shall be removed immediately if such poultry or poultry products are determined by the health authority to be in compliance with the provisions of this Ordinance.

Any person owning or having charge of poultry or poultry products placed under a hold order issued under this Ordinance may request a hearing on the matter before the health authority, under the procedure provided by Section 7 of this Ordinance, and such hearing shall be held within 4 days after it has been requested.

On the basis of evidence produced at the hearing, or on the basis of his examination in the event a hearing is not requested, the health authority may vacate the hold order, or may by written order direct the owner of the poultry and poultry products which were placed under the hold order to denature or destroy such poultry or poultry products or to bring them into compliance with the provisions of this Ordinance: Provided, That such order of the health authority to denature or destroy such poultry or poultry products or bring them into compliance with the provisions of this Ordinance shall be stayed if the order is appealed to a court of competent jurisdiction within 3 days.

The health authority may give written notice, by tag or otherwise, identifying equipment or packaging material he knows or has probable cause to believe will contaminate poultry or poultry products. Such equipment or packaging material shall not be used in the processing or other handling of poultry or poultry products, unless brought into compliance with the provisions of this Ordinance. The health authority shall not so tag or otherwise identify such equipment or packaging material which is immediately brought into compliance with the provisions of this Ordinance.

Any person owning or having charge of equipment or packaging material so tagged or otherwise identified may request a hearing on the matter before the health authority, under the procedure provided by Section 7 of this Ordinance, and such hearing shall be held within 4 days after it has been requested.

On the basis of evidence produced at the hearing, or on the basis of his examination in the event a hearing is not requested, the health authority shall release such equipment or packaging materials or shall, by written notice, direct that they be brought into compliance with the provisions of this Ordinance before being used in the processing or other handling of poultry or

Table 3. Summary of U. S. Standards for Classes of Live, Dressed, and Ready-to-Cook Chickens, 1953

Classes	Live Chickens	Dressed* Chickens	Ready-to-cook** Chickens
Broiler or Fryer	Either sex, young (usually under 16 weeks of age), tender-meated, soft, smooth skin, flexible breastbone.	Not over 4 pounds	Not over 3 1/2 pounds eviscerated weight.
Roaster	Same as for broilers and fryers except usually under 8 months of age, and breast-bones are less flexible.	Weighs over 3 pounds	Over 2 1/2 eviscerated weight.
Capon	Unsexed male (usually under 10 months of age), tender-meated, soft, pliable, smooth-textured skin.	Any weight.	Any weight.
Stag	Male, usually under 10 months of age, somewhat toughened and darkened flesh, coarse skin, considerable hardening of breast-bone, fleshing and maturity between a roaster and a rooster.	Any weight.	Any weight.
Fowl or Hen or Stewing Chicken	Female, mature (usually more than 10 months old), hardened breastbone, less tender than roaster.	Any weight	Any weight.
Cock or Old Rooster	Male, mature, toughened and darkened flesh, hardened breastbone.	Any weight.	Any weight.

*Dressed poultry means poultry which has been slaughtered for human food with head, feet, and viscera intact and from which the blood and feathers have been removed.

**Ready-to-cook poultry means dressed poultry from which the protruding, vestigial feathers (hair or down as the case may be), head, shanks, crop, oil gland, trachea, esophagus, entrails, reproductive organs and lungs have been removed, and with or without the giblets, is ready to cook without need of further processing. It may be cut-up or disjointed.

poultry products: Provided, That when such equipment or packaging material is found by the health authority to be of such nature or in such condition as to be incapable of being brought into compliance with the provisions of this Ordinance, he may direct that it be removed completely from the operating areas of the establishment.

Section 9. Operating Procedures

(a) Operating procedures in poultry-processing establishments shall be such as will assure the production of unadulterated poultry and poultry products.

(b) The following requirements shall be met, and the meeting of such requirements shall be deemed to be compliance with this Section.

(1) Dead birds shall be removed from coops and batteries, and shall be disposed of promptly in such a manner as to preclude use for human consumption.

(2) Feed shall be withheld from live poultry for whatever period may be necessary to prevent materials from the crops from contaminating the outside or inside of poultry carcasses during evisceration.

(3) The slaughter, bleeding, and scalding of poultry shall be conducted in a separate room, or in an area so enclosed or isolated as to prevent dust, blood, splashed

scaldwater, or other resulting wastes from contaminating dressed poultry or other poultry or poultry products. Live poultry shall be placed in bleeding cones, or shall be otherwise suspended for bleeding. The placing of poultry into barrels or on the floor for bleeding is prohibited.

(4) During periods of use, scald tanks shall be supplied with a continuous flow of water into the tank at a minimum rate of 1/4 gallon per carcass scalded per minute. Only clean wax shall be used for the wax-dipping of carcasses, and such wax shall be protected against undue contamination. Before reuse, wax shall be properly cleaned by the use of such equipment and reclaiming procedures as are required by Section 20 (b) (5) of this Ordinance. Wax which falls upon the floor shall be disposed of as waste.

(5) When required in order to remove vestigial hair and down from poultry carcasses, such carcasses shall be singed at some point in the poultry-dressing operation.

(6) If dressed carcasses are vented (i. e., fecal contents are expelled from the cloaca by pressure on the posterior portion of the abdomen) the venting shall be performed under a flow or spray of water in such a manner that the fecal matter is washed away without contaminating the carcass.

(7) Cropping, if conducted, shall be accomplished by forcing the crop contents out through the esophagus and mouth. Incisions through the skin of the neck into the crop shall be prohibited.

(8) As the last step of the poultry-dressing operation, and immediately prior to being eviscerated, each dressed poultry carcass shall be washed by a flow or spray of water, sufficient in quantity and pressure and distributed in such a manner as to clean the outer surfaces of such carcass thoroughly. Immersion of dressed carcasses in a tank of water or other container of water for such purpose shall be prohibited.

(9) Carcasses shall be eviscerated in a sanitary manner with the use of such equipment as is required by Section 20 (b) (6) of this Ordinance. The separation of the inedible from the edible parts shall be accomplished in such a manner that there will be no contamination of edible parts by inedible viscera or other inedible parts. Incomplete evisceration, resulting in a carcass which is not ready-to-cook, shall be prohibited.

(10) Pulling the vent outward and excising it, thus opening the cloaca or terminal part of the intestine into the body cavity of a poultry carcass, is prohibited. Incisions opening the body cavities of carcasses shall be made in such a manner as to prevent cutting or rupture of the intestines.

(11) The giblets shall be separated from the inedible viscera immediately after removal from the body cavity, and shall be immediately cleaned, trimmed, and washed under a continuous flow or spray of water.

(12) Following removal of the viscera, and just before the final wash, bruised portions which are of such extent or nature as to be unsuitable for human consumption shall be trimmed from each carcass.

(13) The inner and outer surfaces of each eviscerated poultry carcass shall be washed by a flow or spray of water. Such water shall be sufficient in quantity and pressure and distributed in such a manner as to clean such carcass thoroughly, or shall be accompanied by such manual or mechanical scrubbing action as shall be necessary to accomplish such cleaning. Immersion of carcasses in a tank or other container of water for such purpose shall be prohibited.

(14) Eviscerated carcasses shall be checked for complete removal of feathers and inedible organs, and shall be trimmed as necessary, before the final inside and outside washing operations. Further trimming, pinning and cleaning shall not be performed on such carcasses after the inside and outside washing operations, unless followed by thorough rewashing in a flow or spray of water in the manner described in paragraph (13) above.

(15) The placing of poultry or poultry products upon the floor shall be prohibited, and if accidentally dropped on the floor, they shall be immediately picked up and thoroughly washed: Provided, That poultry and poultry products which are so soiled or which are of such nature as to preclude adequate cleaning after contact with the floor shall be disposed of as waste matter.

(16) Conveyors, where used, shall be operated at such speeds and under such conditions as will permit processing operations to be conducted in compliance with the provisions of this Ordinance.

(17) Equipment, utensils, and packaging materials shall be so handled as to prevent the contamination of poultry and poultry products. Persons who handle such items or materials

shall use every reasonable precaution to prevent the surfaces which come into contact with poultry or poultry products from coming into contact with their persons, clothing, or contaminating materials.

(18) Eviscerated poultry carcasses, giblets, and cut-up, eviscerated poultry shall be drained to remove free ice and water prior to packaging in the retail container or package.

(19) All operations shall be conducted in such a manner and under such conditions as shall prevent the adulteration of poultry and poultry products which are processed, stored, or otherwise handled in the establishment.

Section 10. Protection of Poultry and Poultry Products from Contamination.

(a) Poultry and poultry products shall be processed, stored, transported, and displayed for sale in such a manner and under such conditions as to be protected against contamination.

(b) The following requirements shall be met, and the meeting of such requirements shall be deemed to be compliance with the section.

(1) Containers and other packaging materials [6] used for packaging poultry and poultry products shall be clean, free from contaminating substances and objectionable odors, and of sufficient strength and durability to protect such poultry and poultry products from contamination during normal transportation and distribution.

(2) Single-service containers and other packaging and wrapping materials whose surfaces come into direct contact with poultry and poultry products shall be purchased in clean cartons or wrappings, stored therein until used, and protected from contamination during storage and use.

(3) Poultry and poultry products packaged in bulk or shipping containers shall be (a) packed in clean containers made of impervious corrosion-resistant materials, with inferior surfaces smooth and free from open seams, breaks, cracks, and chipped places, and so constructed as to provide complete closure and full protection of the contents; or (b) packaged in moisture-resistant containers having waxed interior surfaces or the equivalent thereof; or (c) individually wrapped with clean, moisture-resistant paper and then packed in clean containers; or (d) packed in clean containers lined with moisture-resistant paper in such a manner as to permit such paper to surround the poultry or poultry products completely, with adequate overlapping to permit unsealed closure or sealing in such a manner as to prevent contamination of the enclosed product: Provided, That the bottoms and any paper linings of containers of ice-packed poultry shall have perforations or other openings of sufficient size and number to permit water to drain from such containers as the ice therein melts. Paper used for any of the above purposes shall be of a type and of such strength as not to tear readily during use. Paper once used shall not be used again for wrapping poultry or poultry products, and the use of newspapers for such purpose shall be prohibited.

(4) During processing, storage, transportation, and display for sale, poultry and poultry products shall be protected against contamination from dust, vermin, wastes, insecticides, rodenticides, other toxic and extraneous materials, from overhead leakage and condensation, public handling, coughing, sneezing, and from any other source.

(5) Rodenticides, insecticides, and other toxic materials used in establishments where poultry or poultry products are processed, stored, or otherwise handled shall be identified, stored, and used in such a manner as to preclude the contamination of poultry and poultry products or the creation of other health hazards. Residual-type insecticides shall not be used in poultry processing, storage, or sales rooms where poultry or poultry products may be exposed; only such rodenticides and insecticides as are approved by the health authority shall be used in such rooms.

(6) Enamel-ware containers shall not be used for any purpose in connection with poultry processing.

(7) Flexible water-distribution lines to chilling or thawing tanks or to other receptacles shall be so elevated at all times as to prevent contact with the floor or extension into the contents of such tanks or other receptacles.

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6. "Recommended Specifications for Standard Packs, Containers, and Packaging Materials for Poultry and Poultry Products," Agriculture Handbook No. 25, prepared by the Poultry Branch, Production and Marketing Administration, United States Department of Agriculture, outlines acceptable specifications for some of the various types of containers and packaging materials.

Table 4. Standards for Classes and Specifications Grades of Turkeys, Ducks, Geese, Guineas, and Pigeons, 1953.

Classes	Live	Dressed and Ready-to-cook
	Turkeys	
Fryer or Roaster	Young, immature (usually under 16 weeks of age), either sex, tender-meated, flexible breastbone, soft, pliable, smooth-textured skin.	Not over 10 pounds
Young hen	Young female (usually under 8 months of age), tender-meated, soft, pliable, smooth-textured skin, breastbone somewhat less flexible than fryer.	Any weight.
Young tom	Same as hen, but male	Any weight
Hen	Matured female (usually over 10 months of age), less tender-meated than young hen, hardened breastbone, may have coarse-textured skin and patchy areas of surface fat.	Any weight.
Tom	Same as hen, but male.	Any weight
	Ducks	
Fryer or Broiler Duckling	Young (usually under 8 weeks of age), either sex, tender-meated, bill not completely hardened, easily dented windpipe.	Any weight.
Roaster Duckling	Same as broiler, except age is usually under 16 weeks.	Any weight
Mature or old Duck	Usually over 6 months of age, either sex, toughened flesh, hardened bill and windpipe.	Any weight.
	Geese	
Young	Either sex, tender-meated, easily dented windpipe.	Any weight.
Mature or old	Either sex, toughened flesh, hardened windpipe.	Any weight.
	Guineas	
Young	Either sex, tender-meated	Any weight.
Mature or old	Either sex, toughened flesh.	Any weight.
	Pigeons	
Squab	Young, Immature, either sex, extra tender-meated.	Any weight.
Pigeon	Mature, either sex, coarse skin, toughened flesh	Any weight.

(8) Light bulbs and fluorescent tubage shall be protected against breakage in poultry processing, storage, and sales rooms.

(9) Beverage bottles shall not be permitted in poultry-processing rooms, nor in refrigerated rooms containing poultry or poultry products.

(10) Dogs, cats, and other pets shall be excluded from poultry-processing establishments.

(11) Live poultry shall not be permitted in poultry-dressing rooms, eviscerating rooms, sales rooms, employee toilet or dressing rooms, or refuse rooms, except as provided in Section 11 (b) (5) which permits the killing of poultry in poultry-dressing rooms.

(12) After offal or other wastes are once removed from poultry processing, storage, or sales rooms, they shall not be returned to or transported through such rooms. Wastes shall not be handled or routed within such rooms in any manner which may cause contamination of poultry or poultry products.

(13) Unpackaged or uncovered poultry and poultry products shall not be moved through live-poultry rooms or areas. Poultry and poultry products shall not be moved through refuse rooms.

(14) Receiving, loading, and shipping docks shall not be simultaneously used for the handling of poultry and poultry products and for the handling of live poultry or refuse unless such docks are divided by partitions which separate the operations. Docks or portions thereof which are used for live poultry or refuse shall be thoroughly cleaned before being used for the handling of poultry or poultry products.

(15) All edible materials for use in the processing of canned, breaded, boned, prestuffed or precooked poultry, or in poultry pies, poultry salads, packaged poultry dinners, or other poultry and poultry products, shall be wholesome, free from adulteration and spoilage, and so prepared as to be safe for human consumption. They shall be labeled in a legible form showing correct identification, and shall be purchased, shipped, stored, and handled in such containers and under such conditions as will retain their wholesomeness and protect them from contamination.

Section 11. Construction and General Layout of Poultry-processing Establishments

(a) Poultry-processing establishments shall provide adequate space for poultry processing operations conducted therein; shall be constructed in accordance with the subsequent provisions of this Ordinance, shall be maintained in good repair; and shall provide for the separation of those processes which may cause contamination of poultry and poultry products.

(b) The following requirements shall be met, and the meeting of such requirements shall be deemed to be compliance with this section.

(1) Poultry-processing establishments shall provide sufficient space for the conduct in a sanitary manner of poultry-processing operations carried on therein; for the installation of necessary utility equipment; and for the installation of processing equipment in such a manner so that such equipment will be easily accessible for cleaning.

(2) Poultry-processing establishments shall be constructed in accordance with the subsequent applicable provisions of this Ordinance so as to be easily maintained in a sanitary condition and to prevent harborage areas for rodents, roaches, and other vermin.

(3) Poultry-processing establishments shall be kept in good repair.

(4) Areas for live poultry, such as receiving docks, receiving rooms, holding rooms, and feeding stations, shall be separated by walls extending from the floor to the ceiling and constructed in accordance with the provisions of Section 13 of this Ordinance, from processing, storage, sales, and refuse rooms, and employee toilet and dressing rooms: Provided, That killing or scalding operations which otherwise meet the requirements of this Ordinance may be permitted in a holding room, receiving room, or feeding station, if sufficient space is provided for the conduct of such operations without crowding and the carcasses are immediately removed to the poultry-dressing room for completion of the dressing operation.

(5) Poultry-dressing operations, including removal of feathers, venting, and milking of crops, shall be conducted in a poultry-dressing room which shall be separated from the rest of the poultry-processing establishment by walls extending from the floor to the ceiling and constructed in accordance with the provisions of Section 13 of this Ordinance: Provided, That killing and scalding operations may be permitted in the poultry-dressing room, if conducted in an area so enclosed or isolated as to prevent the contamination of dressed poultry and other poultry and poultry products.

(6) Eviscerating operations shall be conducted in an eviscerating room which shall be separated from the rest of the poultry-processing establishment by walls extending from the floor to the ceiling and constructed in accordance with the provisions of Section 13 of this Ordinance, and such room shall not be used concurrently for any other purpose: Provided, That the final pinning, chilling, cutting-up, grading, thawing, packaging, and packing of dressed and eviscerated poultry may be permitted in an eviscerating room, if sufficient space is provided and such operations are so segregated as to permit their conduct in a sanitary manner.

(7) The further processing of eviscerated poultry, such as the preparation of breaded, boned, smoked, or canned poultry, poultry pies, precooked poultry salads, prestuffed poultry, and packaged poultry dinners, shall be conducted in a room or rooms which shall be separated from the rest of the poultry-processing establishment by walls extending from the floor to the ceiling and constructed in accordance with the provisions of Section 13 of this Ordinance, and such room or rooms shall not be used concurrently for any other purpose.

(8) In poultry-processing establishments where solid wastes from eviscerating and subsequent processing operations are not removed from such establishments and disposed of directly from the points of original collection, refuse rooms shall be provided, separated from the rest of such establishments by walls extending from the floor to the ceiling, and constructed in accordance with the provisions of Section 13 of this Ordinance.

(9) Employee toilet and dressing rooms in poultry-processing establishments shall be separated from the rest of such establishments by walls extending from the floor to the ceiling, and constructed in accordance with the provisions of Section 13 of this Ordinance.

(10) Utility rooms or areas, including boiler rooms, shall be sufficiently isolated, either by such distance or by such walls, floors, and ceilings as may be required, to prevent them from serving as a source of contamination of poultry or poultry products, packaging materials, or processing equipment.

(11) Retail sales rooms for poultry and poultry products or for other products, if operated in the same building as a poultry-processing establishments shall be separated from the rest of such establishment by walls extending from the floor to the ceiling, and constructed in accordance with the provisions of Section 13 of this Ordinance.

(12) If products are prepared for other than human consumption, such operations shall be conducted in rooms which are separated from the poultry-processing establishment by an unbroken wall, or shall be located in a building entirely apart from the building or buildings where poultry and poultry products are processed for human consumption: Provided, That the manufacture of animal-food products consisting entirely of materials fit for human consumption may be conducted in rooms which are separated from the rest of the poultry-processing establishment by walls extending from the floor to the ceiling and constructed in accordance with the provisions of Section 13 of this Ordinance.

(13) Each Poultry-processing establishment shall provide such chilling and freezing facilities as shall maintain poultry and poultry products processed, stored, or otherwise handled therein at such temperatures and under such conditions as are required by the provisions of Section 23 of this Ordinance.

(14) A room or area shall be provided in each poultry-processing establishment where utensils and portable equipment can be cleaned. Such room or area shall be of sufficient size and so located and constructed that the cleaning operations will not contaminate poultry or poultry products or cleaned equipment, and that such room or area is protected from contamination from other portions of the poultry-processing establishment. Such an area shall not be located in a live-poultry room, poultry-dressing room, or refuse room.

(15) Operations not connected with poultry-processing shall not be carried on simultaneously in the same building with poultry-processing unless a solid wall completely separates such operations from the portion of the building where poultry-processing operations are conducted: Provided, That the health authority may authorize solid, self-closing doors in such walls when he determines that such doors will not cause a sanitary hazard to poultry and poultry products; Provided further, That retail sales rooms shall be governed in this regard by the provisions of (b)(11) of this section. No part of a poultry-processing establishment shall open directly into any living quarters.

Section 12. Floors

All floors of poultry-processing establishments shall be kept clean (and reasonably so during operations, and at the end of each operating day) and in good repair. Floors in rooms or areas where poultry is slaughtered, further processed, or stored, and in all other rooms or

areas where floors are not kept dry, (such as where utensils are washed or in refuse rooms) shall be constructed of concrete or other equally impervious and easily-cleanable material, and shall be smooth, graded to drain, and provided with adequate drains.

Section 13. Walls, Ceilings, Partitions, and Posts

In poultry-processing establishments, all walls, partitions, posts, ceilings and exposed overhead structures shall be kept clean (and cleaned after each day of operation) and in good repair, and those in all rooms or areas where poultry or poultry products are processed or stored and in all other rooms or areas where floors are not kept dry, (including refuse rooms and utensil washing rooms) shall be finished with smooth, washable, light-colored surfaces (except cooler and freezer rooms). All outer walls and rooms shall be effectively protected against the entrance and harborage of rodents and insects, and interior walls, partitions, posts, ceilings and overhead structures shall be free from such harborages.

Except for doorway openings, the interior walls separating poultry-dressing rooms, eviscerating rooms, rooms in which eviscerated poultry is processed, retail sales rooms, toilet and dressing rooms, and refuse rooms shall extend from floor to ceiling.

Section 14. Doors, Windows, and Openings

In poultry-processing establishments, all outside openings, including doors, windows, and conveyor openings, shall be effectively protected against the entrance of insects, rodents, and other vermin (except for feeding stations or other live-poultry rooms when they are completely open on one or more sides.) Outside doors, toilet-room doors, and all doors of rooms or areas where poultry is processed, shall be self-closing and close-fitting. All interior doors shall be of a solid type. Doors and windows shall be kept clean and in good repair.

Section 15. Lighting.

All rooms and areas in poultry-processing establishments shall be well lighted.

At least 50 foot-candles of light intensity shall be provided in areas where poultry or poultry products are examined for cleanliness or wholesomeness, at least 30 foot-candles of light intensity on all other working surfaces, and at least 5 foot-candles of light at a distance of 30 inches above the floor in all other areas of the establishment.

Section 16. Ventilation

(a) All rooms and areas in poultry-processing establishments shall be well ventilated.

(b) The following requirements shall be met, and the meeting of such requirements shall be deemed to be compliance with this section.

(1) Sufficient ventilation shall be provided in poultry-processing establishments to dispel disagreeable odors, condensate and vapor. For this purpose, ventilating equipment, such as individual fans, vents, and hoods, shall be provided where needed.

(2) Employee toilet rooms and dressing rooms shall be adequately vented to the outside air.

(3) Space heaters, gas stoves, water heaters, and any other equipment giving off noxious odors, fumes, or vapors shall be vented to the outside air.

(4) Any mechanical ventilating equipment shall be so located and controlled as to minimize conditions in which poultry or poultry products or processing equipment may be subjected to airborne contamination from nearby or preceding operations, or from other sources.

(5) All exhaust outlets from mechanical ventilating devices shall be conducted to the outside air, and shall be so arranged, placed, and extended as to avoid creating a nuisance to adjacent areas.

Section 17. Water Supply

The water supply of each poultry-processing establishment shall be easily accessible, adequate, and of a safe, sanitary quality. (This includes hot water at least 130° F., and no connection to any unsafe or questionable supply).

Section 18. Plumbing and Related Facilities

(a) The plumbing system in each poultry-processing establishment shall be so designed,

installed, and maintained as to protect the plant's water supply, poultry and poultry products, processing equipment, utensils, packaging materials, and containers from contamination through cross-connections, back-siphonage, back-flow, leakage, or condensation. The plumbing system shall readily carry away all liquid wastes. Adequate and conveniently located toilet facilities for employees shall be provided within the establishment. An adequate number of lavatory facilities, supplied with warm water (at least 100° F.), under pressure, soap or other detergent and sanitary means for the drying of hands, shall be located in or near employee toilet and dressing rooms, and at such other places in the establishment as may be necessary for the convenient washing of hands by employees engaged in the conduct of poultry-processing operations. The control valves on those lavatories which are used by employees before beginning or while engaging in the conduct of poultry-processing operations shall be operated other than by hand.

(b) Refrigerators, or other facilities or items of equipment in which poultry or poultry products, utensils, or portable equipment are placed, shall not be directly connected to the drainage system; each waste pipe of such a facility or item of equipment shall discharge into a trapped and vented open sink or receptacle, or into a floor drain, through an airgap at least twice the effective diameter of such waste pipe above the floor-level rim of the sink or receptacle or the drain which receives the drainage therefrom: Provided, That in each refrigerator room which is not equipped with a floor drain, all parts of the floor shall be at least 2 inches above the highest level of the floor of each adjoining room or area into which such refrigerator room opens or drains, and the floor shall be graded to drain to the outside through a waste pipe, doorway, or other opening.

Plant drainage lines shall be separate from toilet sewer lines to a point outside the building.

Where necessary to prevent discharge into the drainage system of feathers, entrails, or similar solid wastes likely to clog the drainage system, the liquid wastes containing such solid materials shall be passed through a separator or indirect-waste receptor which shall effectively retain such solids prior to discharge into the drainage system.

Section 19. Disposal of Wastes

(a) All (liquid and solid) wastes from poultry processing establishments shall be properly disposed of (and not provide food or harborage for rodents, insects or other vermin, or otherwise create a nuisance).

(b) The following requirements shall be met, and the meeting of such requirements shall be deemed to be compliance with this section.

(1) All wastes shall be handled and disposed of in a manner which will prevent possible contamination of the water supply, processing equipment, packaging materials and containers, and poultry and poultry products.

(2) Where septic tanks are used for the disposal of liquid wastes, blood from poultry slaughtering shall be collected in containers constructed of impervious materials and disposed of separately: Provided, That the use of catch basins in floors, with periodic transfer of the coagulated blood to such containers, shall be permitted.

(3) No grease catch-basin, grease trap, or waste disposal unit shall be located in the processing, storage, or sales areas of poultry-processing establishments unless approved by the health authority.

(4) Waste water from processing or other equipment shall not be discharged or drained from the equipment in such manner as will permit flooding of the floor or the flowing of water across working or trucking areas.

(5) After collection, solid wastes shall be held in impervious, water-tight, and easily cleanable containers. Such containers shall be covered with tight-fitting lids and stored on a concrete slab or on a rack which is at least 12 inches above the floor or ground for a single bank of containers; or such containers shall be stored in a refuse room: Provided, That solid wastes from the eviscerating and subsequent processing of poultry shall be immediately placed in such containers, and shall be removed for disposal directly from points of collection and promptly disposed of, or shall be stored only in refuse rooms; Provided further, That if waste water draining therefrom does not create a sanitation problem or a nuisance in processing rooms, on docks or trucks, or elsewhere, feathers which are removed to the refuse room or directly from the premises may be placed in containers which are constructed of impervious material, but which have holes or perforations permitting the drainage of water.

(6) In establishments provided with refruse rooms, solid wastes shall be stored in such rooms, and shall be removed therefrom only for prompt disposal. Such wastes shall be removed from the poultry-processing establishment at least once a day: Provided, That the health authority may approve other disposal schedules.

Section 20. Equipment and Utensils

(a) Such equipment and utensils shall be provided as are necessary for the poultry-processing establishment to conduct all its operations in a sanitary manner. Equipment and utensils shall be of such design, constructed of such materials, and so located as to be easily cleaned, and shall be kept clean and in good repair.

(b) The following requirements shall be met, and the meeting of such requirements shall be deemed to be compliance with this section.

(1) Equipment and utensils in poultry-processing rooms shall be constructed of impervious materials, so designed and fabricates as to facilitate cleaning, so located or placed as to be readily accessible for cleaning, and shall be kept in good repair. In addition, surfaces which contact poultry or poultry products during processing shall be nontoxic, corrosion-resistant, smooth, free from breaks, open seams, cracks, and chipped places, and shall be self-draining where practicable. Such surfaces shall not be constructed of concrete or wood, whether painted or unpainted.

(2) Overhead conveyors and other equipment shall be so constructed and maintained that grease, oil, or dirt from such equipment will not contaminate poultry and poultry products.

(3) Batteries for holding live poultry shall be so constructed as to permit thorough cleaning.

(4) Each tank for scalding poultry shall be provided with facilities to permit water to enter continuously at a minimum rate of 1/4 gallon per carcass scalded per minute, and to flow out through an overflow of sufficient size to prevent clogging.

(5) Equipment shall be provided to catch the wax from wax-dipped poultry. If such wax is to be used again, adequate equipment shall be provided for the conduct of reclaiming procedures, such as skimming, heating and washing, centrifuging, and filtration.

(6) Equipment, such as shackles, trays, bolts, troughs, or stationary or moving-top tables, shall be provided for the sanitary evisceration of carcasses. The surfaces which contact the carcasses or viscera shall be of smooth, nontoxic, impervious, and corrosion-resistant materials. Such equipment shall extend, or shall convey or accompany the carcasses, from the points where the carcasses are first incised or opened for removal of crops or viscera to the points where the viscera, and lungs and other inedible organs, are completely removed.

(7) Each tank or vat used for the chilling or thawing of poultry shall be provided with a drain flush with the lowest interior surface to facilitate cleaning and shall be so constructed that the placing of poultry therein, the removal of such poultry, and the washing and cleaning of such tank or vat may be accomplished without the entry of workers therein.

(8) Facilities shall be provided in each poultry-dressing room for washing dressed carcasses, and in each eviscerating room for washing the inside and outside of eviscerated carcasses. Such facilities or equipment shall be supplied with ample quantities of water under sufficient pressure to wash the carcasses thoroughly and efficiently.

(9) Outlets or facilities providing a continuous flow or spray of clean water for the purpose of rinsing hands and hand-operated items of equipment shall be located within arm's length of persons engaged in removing oil glands, removing crops, cutting vents, otherwise opening the body cavities of carcasses, removing viscera, lungs, reproductive organs or other organs, cleaning or trimming giblets, cutting off shanks, or trimming bruises.

(10) Vats, tanks, receptacles, racks, and similar facilities for the cleaning, rinsing, and bactericidal treatment of portable equipment and utensils shall be provided in a room or area, as specified in Section 11 (b) (14) of this Ordinance, and shall be sufficient in number and capacity to permit adequate cleaning, rinsing, and bactericidal treatment during peak periods of poultry processing.

(11) Bleeding cones shall be constructed of impervious, corrosion-resistant material, and shall be easily accessible or removable to permit thorough cleaning.

(12) Bleeding troughs, if used, shall be of sufficient size and so located as to catch the blood during bleeding operations, and shall be cleaned at least once daily. Such troughs shall be constructed of impervious and corrosion-resistant material; shall be sloped at least 1/2 inch per foot; and shall be flushed continuously with water, or shall drain into catch basins

or containers of sufficient capacity to hold the blood resulting from operations at peak production: Provided, That, if the trough is of sufficient capacity, the blood may be retained therein pending transfer to impervious containers for proper disposal.

Section 21. Cleaning of Equipment and Utensils

(a) Equipment and utensils used in poultry-processing operations shall be thoroughly cleaned by an effective procedure and effectively subjected to bactericidal treatment approved by the health authority, after each day's usage and at such times during operations as may be required to prevent contamination of poultry or poultry products. All other equipment in poultry processing establishments shall be kept in a clean condition.

(b) The following requirements shall be met, and the meeting of such requirements shall be deemed to be compliance with this section.

(1) Equipment and utensils used for processing poultry and poultry products shall be thoroughly cleaned at the end of each day's operations, and at such other times as may be necessary in order to prevent contamination of poultry and poultry products. Such cleaning shall remove grease and other soils, and shall leave no visible surface-film or deposit. Before being put into use, cleaned equipment shall be rinsed with a spray or flow of water. Cleaned equipment and utensils shall be air-dried, unless stored in a protective solution or put into use immediately.

(2) While in use, the cutting surfaces of knives, scissors, shears, clippers, and similar hand-operated instruments used in poultry-processing shall be maintained in a clean condition by frequent rinsing in a flow or spray of water and, when necessary, by the use of such facilities as are required by Section 20 (b) (10) of this Ordinance. When such an instrument becomes visibly contaminated during use, it shall be immediately cleaned, or it shall be laid aside for cleaning and a clean item substituted for use.

(3) Giblet trays, chilling and thawing tanks, and eviscerating trays, troughs, belts, and tables shall be rinsed with a flow or spray of water under pressure after each individual usage, and if such rinsing action is insufficient to remove all visible contamination from such equipment, it shall be supplemented by such other cleaning procedures as will remove such contamination. Grading, sorting, and packing tables and bins shall be effectively rinsed at frequent intervals during periods of usage.

(4) Coops used to transport live poultry shall be cleaned prior to extended storage in a poultry-processing establishment.

(5) Batteries for holding live poultry shall be cleaned thoroughly at least once each week during periods of usage. Dropping pans from such batteries shall be thoroughly scraped at least once every other day when such batteries are in use.

(6) Feed mixers shall be cleaned after each day's use.

(7) Scalding tanks shall be completely emptied and cleaned at the end of each day's operations, and oftener if necessary to maintain reasonably clean scald water under the conditions of operation.

(8) All other equipment shall be kept in a clean condition.

(9) The surfaces of all equipment and utensils coming into contact with dressed poultry or other poultry or poultry products shall, after each day's usage and at such times during operations as may be required to prevent contamination of the poultry or poultry product, be subjected to a bactericidal treatment approved by the health authority.

Section 22. Storage of Clean Utensils, Portable Equipment, and Packaging Materials

(a) Clean utensils, portable equipment, and packaging materials for use in poultry-processing shall be stored in dry, clean locations and in such a manner as to be protected from contamination.

(b) The following requirements shall be met, and the meeting of such requirements shall be deemed to be compliance with this section.

(1) All clean utensils and portable equipment for use in poultry-processing shall be stored above the floor, in clean, dry locations, and protected from splash, dust, and other contamination. Such utensils and equipment shall be air-dried before being stored, or shall be stored in a self-draining position on racks constructed of impervious, corrosion-resistant material: Provided, That storage in protective or other solutions shall be permitted, if equipment and utensils so stored are subsequently washed and rinsed before use.

(2) Single-service containers and wrapping and packaging materials whose surfaces

come into direct contact with poultry or poultry products shall be kept in the original cartons or packages, and shall be stored, until removed for use, in a clean, dry location protected from dust, splash, and other contamination.

(3) Ice shovels, ice tongs, hoses, and nozzles shall be stored on hooks or racks in such a manner as to prevent contact with the floor and to protect them from contamination.

(4) Equipment, utensils, and other items not in current use during processing operations shall not be stored in processing rooms.

Section 23. Temperatures; Chilling and Freezing

(a) Poultry and poultry products shall be chilled or frozen immediately after processing under such conditions and temperatures as will insure prompt removal of animal heat and reduction of the internal temperature of all perishable products to 40° F. or below. During further processing, except when such further processing utilizes heat, the internal temperature of previously chilled poultry or poultry products shall not be permitted to rise above 60° F. During storage, transport, and sales operations subsequent to shipment from the poultry-processing establishment, all frozen poultry and poultry products shall be maintained in a completely frozen state, and all other poultry and poultry products, except those heat-processed in hermetically sealed containers, shall be maintained at or below 50° F.

(b) The following requirements shall be met, and the meeting of such requirements shall be deemed to be compliance with this section.

(1) In poultry-processing establishments, poultry carcasses to be chilled in vats, tanks, or similar containers shall be placed therein immediately after the final washing of such carcasses. The chilling medium in such containers, such as refrigerated water or ice slush, shall be maintained at 40° F. or below during all periods when carcasses are being chilled or held in such medium. Poultry carcasses weighing less than 4 pounds shall be chilled to 40° F. or below in less than 4 hours; carcasses weighing 4 to 8 pounds shall be chilled to 40° F. or below in less than 6 hours; and carcasses weighing more than 8 pounds shall be chilled to 40° F. or below in less than 8 hours. In order to facilitate continuous processing operations, carcasses may be held overnight in such containers of refrigerated water or ice slush of a temperature of 40° F. or less, but in no case shall carcasses be held in direct contact with either or such media for a period longer than 24 hours. If carcasses are to be held in such chilling containers for longer periods than specified herein, they shall be removed from the refrigerated water or ice slush and properly packed with crushed ice in clean containers which are continually drained, and, during this holding period, the temperature of the carcasses shall be maintained at or below 40° F.

(2) Carcasses which are to be air-chilled shall be placed in a refrigerated room with moderate air movement and a temperature of 36° F. or below. The carcasses shall be so spaced, and conditions shall be such, as to reduce the internal temperature of such carcasses to 40° F. or below within 24 hours from the time of slaughter.

(3) Giblets shall be chilled to 40° F. or below within 2 hours from the time they are removed from the inedible viscera. Any of the approved methods for the chilling of carcasses may be used in chilling giblets: Provided, That unwrapped livers shall not be chilled in refrigerated water or ice slush, but may be chilled in direct contact with chipped ice or manufactured snow in shallow containers which are continually drained.

(4) If poultry carcasses and other perishable poultry or poultry products are chilled by methods and in facilities other than those described in the provision of (b)(1), (2), or (3) above, they shall be placed in such chilling facilities immediately after slaughter and other initial processing. Such facilities shall maintain temperatures of 36° F. or below. The internal temperature of poultry and poultry products shall be reduced to 40° F. or below within 24 hours from the time of slaughter.

(5) Coolers in poultry-processing establishments where poultry or poultry products are chilled, or where chilled poultry or poultry products are stored, shall be maintained routinely at a temperature of 36° F. or below.

(6) All freezer facilities used for poultry or poultry products shall be maintained at temperatures of 0° F. or below. Poultry and poultry products to be frozen shall, if the internal temperature thereof is 40° F. or below, be placed in freezing facilities providing temperatures of 0° F. or below, under such packaging, air-circulation, and stacking conditions as shall result in prompt and efficient freezing throughout. If the internal temperature thereof is above 40° F., such poultry or poultry products shall be placed in a plate-freezer or in a

freezer with a functioning, circulating-air system where a temperature of -20° F. or below is maintained. Such poultry or poultry products shall remain in freezer facilities until completely frozen.

(7) Poultry and poultry products which have been frozen or chilled to 40° F. or below shall be held in a frozen state or at 40° F. or below, as the case may be, until shipped from the poultry-processing establishment, unless further processed prior to such shipment. During further processing, except when such further processing utilizes heat, the internal temperature of poultry and poultry products shall not be permitted to rise above 60° F.

(8) Immediately after being further processed, as described in (b) (7) above, or after being processed by the utilization of heat, poultry and poultry products, except those immediately heat-processed in hermetically sealed containers, shall be placed in chilling or freezing facilities maintained at temperatures of 36° F. or below. The internal temperature of such poultry and poultry products placed therein shall be reduced to and held at 40° F. or below until the products are shipped from the poultry-processing establishment establishment.

(9) All perishable, edible materials for use in the processing of canned, breaded, prestuffed, or precooked poultry, or in poultry pies, poultry salads, packaged poultry dinners, or other poultry or poultry products, shall be kept refrigerated at a temperature below 50° F., except when being prepared.

(10) Poultry and poultry products shall be chilled to an internal temperature of 40° F. or below before being shipped from poultry-processing establishments; however, such a requirement may be waived by the health authority if such poultry or poultry products, within 2 hours from the time of slaughter, are further processed by the use of heat, or are placed in a plate-freezer or a freezer with a functioning, circulating-air system where a temperature of -20° F. or below is maintained: Provided, That such freezer facilities are so located that the health authority has access thereto and had adequate opportunity to determine compliance with the time and temperature requirements of this paragraph.

(11) During transportation, storage, and display subsequent to shipment from poultry-processing establishments, the internal temperature of poultry and poultry products, except those heat-processed in hermetically sealed containers, shall be maintained at or below 50° F. Whenever necessary to maintain product-temperatures at 50° F. or below, or to prevent the thawing of frozen products, refrigerated vehicles shall be used for transporting poultry and poultry products.

(12) The defrosting and refreezing of poultry and poultry products shall be prohibited: Provided, That such defrosting and refreezing may be conducted in a poultry-processing establishment when essential to a further processing operation which substantially changes the nature of the product. Frozen poultry or poultry products shall be defrosted only for further processing, and shall be so processed on the same day, directly after they have been thoroughly defrosted; complete or partial defrosting of frozen poultry or poultry products during storage, transportation, or sales operations shall be prohibited: Provided, That such poultry or poultry products may be defrosted in a retail establishment immediately prior to being cooked for retail sail in such establishment.

(13) When packaged or unpackaged poultry products are defrosted by being permitted to thaw, the temperature of the air in the facility in which such defrosting takes place shall not exceed 50° F.

(14) If frozen poultry or poultry products are submerged in water for defrosting, the temperature of the water in the thawing tank or vat shall not exceed 70° F. A continuous flow of water through the thawing tank or vat shall be provided, and the rate of flow shall be sufficient to keep the water in the tank or vat clear. If defrosting is accomplished by placing the product in perforated or mesh-type containers under sprays of water, the temperature of the water shall not exceed 70° F., the water shall be sprayed upon the product continuously and shall drain readily from the container, and the bottom of the container shall be raised above the floor on legs or other supports.

(15) Ice used for the chilling, ice-packing, or iced display of poultry and poultry products shall be manufactured ice of a safe, sanitary quality. All such ice shall be stored and handled in such a manner as to prevent its being contaminated. Block ice shall be placed on clean pallets or platforms; and washed by spraying the outer surfaces with water immediately before such ice is crushed. Ice-crushing machines shall be thoroughly washed before and after each day's use. No person shall be permitted to stand or walk on ice washing pallets of platforms.

(16) Barrels, wirebound boxes and baskets, and other containers in which poultry and poultry products are packed with ice shall have sufficient openings for drainage of water from such containers, and shall be so covered during transport and storage as to prevent contamination of poultry and poultry products contained therein. Covers of such containers shall be substantial, tight-fitting, and fastened securely in place when in use.

(17) All vehicles, refrigerators, refrigerator rooms, and display cases in which poultry and poultry products are transported, stored, or offered for sale shall be free of objectionable odors and maintained in a sanitary condition. Condensate shall not be permitted to form or accumulate in such quantity or under such conditions as to drip upon poultry or poultry products or containers thereof.

Section 24. Premises

The immediate premises of poultry-processing establishments shall be kept in a clean, neat condition, and free from refuse, waste materials, and other sources of objectionable conditions.

Section 25. Cleanliness of Personnel

Persons who engage in poultry-processing operations, or in duties during which they contact poultry-processing equipment or utensils, and persons who contact poultry or poultry products during storage or sales operations, shall wear clean, washable garments, keep their hands clean, and conform to hygienic practices during all periods of such duties. Adequate facilities shall be provided in poultry-processing establishments for the storage of employees' clothing.

Section 26. Health of Personnel

(Same as for other food handlers.)

Section 27. Poultry and Poultry Products from Other Jurisdictions

Poultry and poultry products from points outside the jurisdiction of the Municipality of _____ shall not be sold or further processed within the Municipality of _____ or in its police jurisdiction, unless adequately identified as previously processed and packed under the supervision of a department of Federal, [7] State or local government, and under provisions which are substantially equivalent to the requirements of this Ordinance. The health authority may accept reports from the responsible authority of the jurisdiction where the processing establishment is located, to determine the extent of compliance with such equivalent requirements and permit receipt of poultry from such jurisdiction if regulations substantially equivalent to the provisions of this Ordinance are effectively enforced in relation to such poultry.

Section 28. Penalties

(Same as for other food sanitation violations.)

Section 29. Repeal and Date of Effect.

This Ordinance shall be in full force and effect 12 months after its adoption and publication as provided by law and, at that time, all ordinances and parts of ordinances in conflict with this Ordinance are hereby repealed.

Section 30. Severability

Should any section, paragraph, sentence, clause, or phrase of this Ordinance be declared unconstitutional or invalid for any reason, the remainder of such Ordinance shall not be affected thereby.

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(7) The sanitation provisions of the Regulations Governing the Grading and Inspection of Poultry and Edible Products Thereof and United States Classes, Standard, and Grades with Respect Thereto, Part 70 of Title 7 of the Code of Federal Regulations, in effect March 1, 1955, are substantially equivalent to the provisions of this Ordinance. Therefore, poultry and poultry products from poultry-processing establishments complying with these regulations should be considered acceptable to jurisdictions, under the provisions of this section.

Grades

U.S. Grade A or U.S. No. 1. Any lot of live poultry may be designated as U. S. Grade A or U.S. No. 1 if at least 90 percent, by count, of the birds be of A Quality or No. 1 Quality and the remainder be of B. Quality or No. 2 Quality. When more than one container comprises the lot, no container shall have more birds of B Quality or No. 2 Quality than that specified in the following table:

U.S. Grade B or U.S. No. 2. Any lot of live poultry may be designated as U.S. Grade B or U.S. No. 2 if at least 90 percent, by count, of the birds be of B Quality or No. 2 Quality, or better, and the remainder be of C Quality, or No. 3 Quality. When more than one container comprises the lot, no container shall have more birds of C Quality or No. 3 Quality than that specified in the following table:

Table 5. Grading for U. S. Grade A

When Lot Consists of More Than 1 Container

Grade	Number of birds in container	Maximum number of B quality or No. 2 quality birds
U.S. Grade A or U.S. No. 1	Less than 10	1 bird
	10 to 15 inclusive	2 birds
	16 to 20 inclusive	3 birds
	21 to 25 inclusive	4 birds
	26 or more	5 birds

Table 6. Grading for U. S. Grade B

When Lot Consists of More than 1 Container

Grade	Number of birds in container	Maximum number of C quality or No. 3 quality birds
U.S. Grade B or U.S. No. 2	Less than 10	1 bird.
	10 to 15 inclusive	2 birds.
	16 to 20 inclusive	3 birds.
	21 to 25 inclusive	4 birds.
	26 or more	5 birds.

U.S. Grade C or U. S. No. 3. Any lot of live poultry may be designated as U.S. Grade C or U.S. No. 3 if it consists of birds of not less than C Quality or No. 3 Quality.

The term "No Grade" is not a grade. Such term may be applied to any lot of live poultry if such lot contains any birds of less than C Quality or No. 3 Quality or has not been graded in accordance with this section.

United States Standards for Quality of Dressed Poultry and Ready-to-cook Poultry.

Carcasses found to be unsound, unwholesome, or unfit for food shall not be included in any of the quality designations specified in this section. If the carcass be dressed poultry, determination of unsoundness or unwholesomeness will be based on external characteristics only.

The quality designations specified in this section may not be made applicable to dressed poultry that is not free from the following conditions: Dirty head; bloody head; dirty carcass; bloody carcass; dirty vent; dirty feet; fan feathers on the wing tips; garter feathers around the hock joints; neck feathers; and, if the crop be not removed, feed in the crop.

The A Quality designation may not be made applicable to any poultry carcass if the poultry were wet picked in such a manner that the skin has been damaged by extended immersion in, or high temperature of, the water which resulted in immediate discoloration or may result in later objectionable discoloration.

In interpreting the respective requirements specified in this section for A quality, B quality, and C quality, (See Table 7) the intensity, aggregate area involved and locations of discolorations (whether or not caused by dressing operations), bruises, pinfeathers, and freezer burn, as such defects individually, or in combination, detract from the general appearance of the carcass, will be considered in determining the particular quality of an individual carcass.

Table 7. Summary of United States Standards for Quality of Dressed Poultry, and Ready-to-cook Poultry, 1953. (Individual Carcasses)

Quality Factors	A Quality	B Quality	C Quality
Conformation	Same as for live poultry, (see Table 7)	Same as for live poultry.	Same as for live poultry.
Fleshing	Same as for live poultry, except that young tom turkeys may have slight thickening and pouchiness of skin on forepart of breast.	Sufficiently fleshed breast and legs to prevent appearance of thinness and prominence of breast-bone.	Poorly fleshed; young tom turkey may have thick, coarse skin and flabby or pouchy extended breast.
Fat Covering	Same as for live poultry.	Sufficient coverage on breast and legs to prevent appearance of flesh through skin.	Lacking coverage over entire carcass.
Pin Feathers	Practically free especially on breast.	Slight scattering over carcass, but few on breast.	Numerous over carcass for dressed poultry. No protruding but some non-protruding pin feathers and few vestigial feathers for ready-to-cook poultry.
Cuts, Tears, Disjointed and Broken Bones	Free on breast and legs, aggregate length of cuts or tears on rest of carcass not more than 1 1/2 inches (turkeys and geese, not more than 3 inches.) No sewn tears or cuts. May have one disjointed bone (either leg or wing); one non-protruding broken bone also in case of chicken broiler or fryer. No bruise marks.	Tears and cuts on breast and legs more than 1 1/2 inches; on rest of carcass not more than 3 inches. For geese and turkey, not more than 3 inches on breast and legs, nor 6 in. elsewhere on carcass. No sewn tears or cuts. Not more than 2 disjointed bones (legs or wings), also one broken bone non-protruding (leg or wing). No bruise marks.	Torn skin, disjointed and broken bones but with no evidence of related severe bruise or blood clot. No sewn tears or cuts.
Discoloration	Bruises and blemishes least on breast and legs. Aggregate area on breast and legs, not more than 1 in. in diameter (for geese and turkeys, not more than 2 inches diameter). Aggregate area elsewhere on carcass not more than 1 1/2 in. in diameter (for geese and turkeys, 3 in. diameter). The skin may show only slight reddening in feather follicles on neck, near head, and on wings.	Bruises and blemishes least on breast and legs. Aggregate area on breast & legs, not more than 1 1/2 in. in diameter (for geese & turkeys, not more than 3 in. in diameter). Aggregate area elsewhere on carcass, not more than 3 in. in diameter (for geese & turkeys, 6 in. in diameter.) The skin may show only moderate reddening in feather follicles on the neck, near head, and on wings and thighs.	Numerous and large discolored areas or blemishes of skin; some reddening and darkening of flesh beneath, but so as not to render the part of carcass unfit for food.
Freezer Burns	Slight; none of the few areas should exceed 1/8 in. in diameter.	Moderate; no area exceeding 1/2 in. in diameter.	More than moderate

United States Grades for Dressed Poultry and Ready-to-cook Poultry.

When any lot of dressed poultry is graded on the basis of an examination of each carcass in a representative sample thereof, any carcass that would be of A Quality, if it did not possess any of the following conditions shall be considered as being of B Quality: Dirty or bloody head or carcass, dirty feet or vent, fan feathers or neck feathers or garter feathers, or feed in the crop. Any carcass that would be of B Quality or C Quality if it did not possess any of the foregoing conditions shall be considered as being of C Quality.

The suggested weight specifications for dressed poultry and ready-to-cook poultry are not incorporated in the grades, since weight, as such, is not a factor of grade. It is recommended, however, that each container of dressed poultry and ready-to-cook poultry contain carcasses of the weights specified.

Grades.

U.S. Grade A. Any lot of dressed poultry or ready-to-cook poultry composed of one or more containers of carcasses of the same kind and class may be designated as U.S. Grade A if not less than 90 percent, by count, of the carcasses in such lot be of A Quality, the remainder of B Quality, and no individual container in such lot contains more carcasses of B Quality than in the proportion of 2 to each 12 carcasses in the container.

Fig. 1. Example of Grade Mark for Ready-to-cook Poultry

U.S. Grade B. Any lot of dressed poultry or ready-to-cook poultry composed of one or more containers of carcasses of the same kind and class may be designated as U.S. Grade B if not less than 90 percent, by count, of the carcasses in such lot be of at least B Quality, the remainder be of C Quality, and no individual container in such lot contains more carcasses of C Quality than in the proportion of 2 to each 12 carcasses in the container.

U.S. Grade C. Any lot of dressed poultry or ready-to-cook poultry may be designated as U.S. Grade C if it consists of carcasses of not less than C Quality.

Fig. 2. Example of Form of Inspection Mark for Inspected and Certified Edible Product

Eggs.

The term eggs usually means only chicken eggs, although the eggs of other birds may be used as food. The fact that eggs are perishable and are provided for mass consumption requiring transportation for long distances and storage for extended periods has brought egg production, storage and distribution into public health as an important problem.

Eggs and Disease. Diseased birds may transmit the pathogenic organism to the egg. The organisms causing paratyphoid fever, typhoid fever, food poisoning, streptococcic infection and avian tuberculosis have been isolated from eggs. Experimentally, typhoid, paratyphoid, cholera, enteritis, and botulism organisms have been found to penetrate the egg shell. Microorganisms penetrate the egg shell more rapidly at high humidities. Molds develop in the egg as well as on the shell. At a temperature of 50° F. and a relative humidity of 100, molds develop in 5 days. As the temperature and relative humidity decrease molding is delayed. Wet and dirty eggs may develop a musty odor by the penetration through the shell of the psychrophile Achromobacter perolens. The following types of bacteria have been isolated from fresh eggs: Staphylococcus aureus and albus and other staphylococci, Bacillus subtilis, Escherichia coli and related organisms, the proteus group, streptococcus group, micrococci, streptothrix, diphtheroid bacilli, putrefactive anaerobes, Pseudomonas fluorescens, molds, Bacillus mucosus, spirillum, and salmonella.

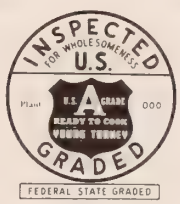

Fig. 3. Example of Combined Form of Grade and Inspection Mark

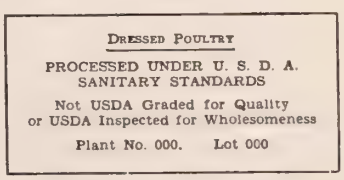
DRESSED POULTRY
PROCESSED UNDER U. S. D. A.
SANITARY STANDARDS
Not USDA Graded for Quality
or USDA Inspected for Wholesomeness
Plant No. 000. Lot 000

Fig. 4. Label for Dressed Poultry Which Has Been Graded or Inspected for Condition Only.

Various investigators have found from 9% to 24% of eggs infected with various microorganisms. All types of processed

eggs have been found containing various microorganisms. The use of raw eggs, especially for making dressings, may therefore be a hazard. Freshly laid eggs from healthy fowl are usually sterile. The relatively impervious shell and the bactericidal properties of egg white help to keep eggs sterile. Mishandling vitiates this natural protection. The important causes of deterioration of eggs are infection and enzyme action.

Conservative sources estimate that boiling eggs 8 to 10 minutes and allowing them to cool slowly kills salmonella organisms, but not when cooled rapidly. However, recent research in the pasteurization of eggs indicates that infected eggs may be disinfected at lower temperatures and shorter time. Frying does not always kill salmonella.

Preservation of Eggs. The quality of eggs are preserved by:

1) Selecting eggs from healthy poultry.
2) Cleaning unclean eggs soon after collection.
3) Eliminating spoiled eggs before storing.
4) Protecting eggs against undesirable odors.
5) Protecting eggs against heat.
6) Storing at proper temperature and humidity.
7) Controlling CO_2 content in air of storage rooms.
8) Closing pores of shell by dipping.
9) Pasteurization of eggs.

Eggs should be gathered, as much as possible, from healthy flock raised under sanitary conditions since diseased birds and unsanitary environment may cause infection or contamination of eggs.

Unclean eggs are cleaned by (a) treatment with dilute sulphuric acid, (b) wiping with wet cloth or brush, (c) washing with soap and water, (d) sand-blasting. The cleaning of dirty eggs usually causes the removal of the protective protein covering on the shell. Such a process would reduce the keeping quality of an egg, but would impair the keeping qualities less than the presence of dirt on the shell.

Spoiled eggs may damage neighboring sound ones, therefore all eggs should be candled before placing them in storage.

Cleanliness and sanitation are important to keep down spoilage and foreign odors. Between seasons, warehouses should be cleaned by scrubbing and spraying with a sanitary dressing of cold water paint, hygroscopic salt, or whitewash. All litter should be continually removed. Some warehouses circulate ozone through the plant to sweeten foul air.

Fresh eggs should be handled or stored as soon as possible so as to protect them against warmth. When placed in storage, stacks should be arrayed to allow plenty of circulation to prevent warm air pockets. The best temperatures for cold storage are between 28° to 31° F. Such temperature usually decreases the humidity, causes moisture from eggs to evaporate, and thereby increases the size of the air-cells in the eggs. It is therefore important to keep the humidity in storage rooms around 85 to 93%, but in doing so, air circulation should be maintained to prevent too moist air pockets from forming in which molds thrive. If eggs be allowed to freeze, the contents expands and causes the shell to break.

It has been demonstrated that when eggs lose too much carbon dioxide on standing in storage, deterioration of the egg sets in. This has led some to charge the air of warehouses with 1 to 2 1/2 percent carbon dioxide.

To prevent the absorption of odors, loss of moisture and carbon dioxide, a process of dipping eggs in hot (130° F.) mineral oil for a few seconds to close the pores in the shell has been developed. Waterglass is used in households for covering eggs to preserve them. This material has antiseptic qualities and is effective in preserving eggs.

The specific factors related to the deterioration of the quality of eggs in cold storage, and against which preventive measure must be taken are:

1) Loss of moisture from the egg white by evaporation.

2) The passing of water from the egg white to the yolk.
3) The decreased viscosity of the white which causes an increased motility of the yolk.
4) The weakening of the yolk membrane causing the flattening of the yolk when the egg is broken.
5) The loss of CO_2 from the egg.
6) The decomposition of the protein and fat of the egg.
7) The absorption or development of odors or flavors.

The older the egg the more likely is it that the above conditions will set in. Age plus heat will cause the germ spot in the egg to develop so that a blood spot or blood ring will form and the yolk will become a deeper color. Fertile eggs are much more liable to rot than sterile eggs. The first stage of decomposition is called "white rot" or "water rot", or "addled egg" or "sour". The next more advanced stage of decomposition is called "mixed rot." The interior is thin, gives off H_2S, is sour, and the yolk is rarely intact. The advanced stage of decomposition is called "black rot". The contents are mixed, very watery, dark, and gives off H_2S. "Mold spots" are produced by growth of molds.

Recent work has demonstrated that eggs in shell can be effectively pasteurized at a temperature of 146° F. A machine has been developed whereby the eggs are carried on belts through a trough containing hot water thermostatically controlled. The eggs are continually rotated as they pass under brushes which clean them. Then they are quickly cooled and dried. The breakage is negligible. A thin layer of the albumin is coagulated on the inner surface of the shell which provides the eggs with protection against bacterial penetration and also stabilizes the albumin so that the normal thinning of the albumin on standing is retarded greatly. The eggs so treated retain the fresh broken-out appearance longer than untreated eggs. The same machine may be used to cover the eggs with a fine oil spray, or to transfer the eggs to a pulping apparatus, if pulping be desired. It is estimated that about 18,000 eggs per hour can be washed, scrubbed, pasteurized, dried and, if desired, pulped.

Frozen and Dried Eggs.

Frozen eggs. Eggs that are unmarketable but edible such as are cracked, over-or-undersized, off-color, dirty or too weak to ship are salvaged by freezing. They are first carefully candled, then the contents are emptied from the shells, frozen at -12° to -15° F. for 72 hours, and then held at 0° to -5° F. Freezing interferes with the emulsifying property of the yolk, but the addition of 10-20% glycerine, 5 to 10% sugar, or 5 to 10% salt lowers the freezing point and preserves this property. Freezing egg yolk at 20°F. and storing at 0° F. for two or three weeks kills more than 95% of the standard plate count bacteria and all of the coliform. Pasteurization of whole egg and yolk before freezing appears to preserve their value for making mayonnaise when judged by consistency, stability, and palatability of the stored product. Mayonnaise made with 13.5% defrosted plain yolk is too stiff to be readily acceptible. As the percent of defrosted yolk in mayonnaise is decreased from 13.5% to 5.5%, the stiffness and stability of the mayonnaise declines. There are 3 classes of frozen eggs, namely, frozen whole eggs, frozen yolks, and frozen whites. These are used commercially in baking, making candies, mayonnaise, ice-cream, etc. The freezing of eggs has become a big industry. Unless high quality eggs be used, the bacterial content may be very great and the spoilage very rapid. Frozen eggs prepared from poor quality may yield bacterial counts of 4 million to 1 billion per gram.

Dried Eggs. In this country, dried eggs are produced by churning edible quality liquid whole eggs into a smooth mixture and forcing this through a pressure pump at 1,500 to 3,000 pounds of pressure. The sprayed material is kept at a temperature of 160° to 220° F. until it dries into a fine powder.

Dried albumin is prepared by fermentation of the egg white in large vats, after which ammonia is added to neutralize the acids formed. Then it is placed on trays in a room at about 120° F. and allowed to dry. The standards of the U.S. Army Quartermaster Corps for dried eggs are that: The bacterial plate count per gram should not exceed 150,000 organisms; the coliform count should not exceed 100 per gram; and the yeast and mold count should not exceed 100 cells per gram.

Liquid Egg. Few food products are more perishable than eggs when they have been removed from their shells. Spoilage is greatly inhibited, however, by using high-quality eggs and breaking them under strictly sanitary conditions. Liquid eggs are liable to be heavily seeded with bacteria.

Liquid egg products that are to be processed into dried eggs are also effectively pasteurized. Whereas 99% or more of the Salmonella germs are destroyed in the spray-drying process by preheating, about 38% of the Salmonella will survive if preheating be not practiced. The following table indicates the temperature-time relation for pasteurizing liquid egg product effectively.

Table 68. Time-temperature Relation for Pasteurizing Liquid Egg Product

Group I* Salmonella Destroyed	Group II** Salmonella Destroyed
148° F. - - - within - - - - 0.8 minutes	- - - - - - - - - 1.6 minutes
144° F. - - - " - - - - 1.2 "	- - - - - - - - - 3.6 "
140° F. - - - " - - - - 2.6 "	- - - - - - - - - 6.7 "
138° F. - - - " - - - - 3.7 "	- - - - - - - - - 8.5 "

*Group I includes Salmonella pullorum, oranienburg, montevideo, tennessee, meleagridis, london, mewington, derby, rubislaw, oregon, and kentucky.

**Group II includes group I plus Salmonella senftenberg and cerro.

The higher the temperature and the longer the time of operation, the greater is the formation of a film on the inside of the preheater tubes.

Pasteurization of liquid egg products greatly reduces the standard plate count bacteria, destroys possible pathogenic bacteria such as Salmonella, and prolongs the keeping time of the products. Freezing and storage of liquid egg products also reduce the viable bacterial count, but not to such an extent as pasteurization. Pasteurization and freezing impair the value of egg products only slightly, if at all, for making angel and sponge cakes and custards. Pasteurization of the whole egg at 140 to 146° F. for four minutes kills more than 99 percent of the standard plate and coliform bacteria present. This pasteurization temperature and time kills all the bacteria in the yolk. Freezing egg yolk at 20° F. and storing at 0° F. for two to three weeks kills more than 95% of the standard plate count bacteria and all of the coliforms.

Inspection of Eggs. Eggs are inspected primarily for freshness, soundness, size, cleanliness of shell, and sometimes for color. The freshness of an egg can be determined by candling or breaking a certain number at random and examining for mustiness, sourness, and other signs of deterioration. Candling, which is usually done in a dark room, is accomplished by holding an egg by hand in front of a small lighted orifice so that a relatively strong light beam about the diameter of a half-dollar will enable a fairly distinct observation of the condition of the egg contents. The egg is held so that the air cell is uppermost and is turned slowly so that the movement of the yolk may be noted. Unsound eggs are detected by the following signs:

1. The degree of visibility of the yolk and germ. The latter is small and irregular in infertile eggs, and large and round in fertile eggs.
2. The size of the air cell.
3. The degree of mobility of the yolk.
4. The presence of blood spots or blood rings.
5. The presence of heavy mottling or abnormal discoloration of yolks.
6. The presence of movable air spots.
7. The presence of discolored whites.
8. The presence of visible bodies such as a chick embryo.
9. The presence of cracks in the shell.
10. The adherence of the yolk in the shell.
11. The mixing of the white and the yolk.

When the following conditions are found in eggs, they should be rejected as unfit for food: Moldiness, blood ring or blood spot, black spots, adherent yolk, black rot, partly hatched, decomposed, putrid, or filthy, subjected for any period of time to incubation.

If the quality of eggs be determined by candling, those eggs candled some period of time prior to reaching the consumer may undergo a number of changes in quality during the interval. It is also known that candling alone does not reveal quality as well as candling plus the appearance of egg sample when broken out of the shell. This situation has led to considerable agitation to express quality of eggs on the basis of what it should be when broken out instead of only how it appears to be by candling. The Poultry and Egg National Board Consumer Information Service, has issued a grading chart (Chart 14) which takes into consideration the appearance of the egg when candled, broken out, hard boiled, and fried. In this chart, the grades designated for candled eggs are the same as those set up by the Department of Agriculture in January 1943.

Egg-breaking Sanitation.

The sanitary requirements for egg-breaking for frozen egg production is the same as for dried egg production. Eggs should be under refrigeration until ready for breaking.

Eggs should be candled before breaking. Only edible eggs should be used. Inedible eggs should not be mixed with edible eggs cracked for freezing, drying, or other treatment whereby the unfit eggs would lose their identity and become inseparably mixed with edible eggs. The egg-breaking room should be well-lighted, and all the equipment should be easily disassembled, cleaned and sterilized. Table tops and belts should be made of stainless steel. Egg cups should not be made of glass because of breaking or chipping. Chairs or stools should be metal or enameled. Walls and floors should be made of non-absorbent material and kept clean. The operators should wear hairnets or caps, and preferably uniforms also. Their fingers and hands should be inspected daily. No operator with a communicable disease or a skin infection should handle any of the egg products. Control methods used by the operators should be close to surgical sterility. The breaking apparatus must be sterilized if a single poor egg contaminates it. Every operator should be medically examined before employment. Adequate toilet and lavatory facilities should be provided, with ample and convenient means for washing and drying the hands, and signs should be prominently posted to encourage this practice. Locker rooms, sanitary plumbing and adequate lighting, heating and ventilation contribute to quality of product and health of employees. Bacteriological examination should be made of the equipment to insure proper cleaning and freedom from accumulations of microorganisms or putrefactive products.

Regulations Governing the Grading of Shell Eggs and United States Standards, Grades, and Weight Classes for Shell Eggs Issued by the Consumer and Marketing Service of the U.S. Department of Agriculture (Agricultural Marketing Act, 1946, as amended), August 1967.

Definitions

Administrator means the Administrator of the Consumer and Market Service of the Department of Agriculture or any other officer or employee of the Department to whom there has heretofore been delegated, or to whom there may hereafter be delegated the authority to act in his stead.

Applicant means an interested party who requests any grading service, appeal grading, or regrading with respect to any product.

Case means, when referring to containers, an egg case, as used in commercial practice in the United States, holding 30 dozens of shell eggs.

Class means any subdivision of a product based on essential physical characteristics that differentiate between major groups of the same kind, species, or method of processing.

Condition means any condition (including, but not being limited to, the state of preservation, cleanliness, soundness, wholesomeness, or fitness for human food) of any product which affects its merchantability.

Department means the United States Department of Agriculture.

Eggs of current production means shell eggs which have moved through usual marketing channels since the time they were laid and have not been held in refrigerated storage in excess of 30 days. "Refrigeration or storage eggs" means shell eggs which have been held under refrigeration for a period of more than 30 days.

Grader means any employee of the Department authorized by the Secretary, or any other person to whom a license has been issued by the Secretary, to investigate and certify, in accordance with the act and this part, to shippers of products and other interested parties the class, quality, quantity, and condition of such products.

Grading certificate means a statement, either written or printed, issued by a grader pursuant to the act, relative to the class, quantity, quality, or condition of products.

National supervisor means (1) the officer in charge of the poultry grading service of the Consumer and Marketing Service, and (2) such other employee of the Service as may be designated by him.

Office of grading means the office of any grader or sampler.

Official plant means any plant in which the facilities and methods of operation therein have been found by the Administrator to be suitable and adequate for grading service in accordance with this part and in which grading service is carried on.

Origin grading is a grading which is performed other than where the eggs are retailed or consumed.

Product or products means shell eggs of the domesticated chicken.

Sampler means any employee of the Department authorized by the Secretary, or any other person to whom a license has been issued by the Secretary, to draw samples of products for grading by a grader or for lot analysis under the act and this part.

Sampling report means a statement, either written or printed, issued by a sampler, identifying samples taken by him for grading.

Secretary means the Secretary of the Department of Agriculture or any other officer or employee of the Department to whom there has heretofore been delegated, or to whom there may hereafter be delegated, the authority to act in his stead.

Service means the Consumer and Marketing Service of the Department.

Shell eggs means eggs of domesticated chickens.

Shell protected means eggs which have had a protective covering such as oil applied to the shell surface. The product used shall be acceptable to the Food and Drug Administration.

Official certificate means any form of certification, either written or printed, used under this part to certify with respect to the sampling, class, grade, quality, size, quantity, or condition of products (including the compliance of products with applicable specifications).

Official memorandum means any initial record of findings made by an authorized person in the process of grading or sampling pursuant to this part, any processing or plant-operation report made by an authorized person in connection with grading or sampling under this part, and any report made by an authorized person of services performed pursuant to this part.

Official mark means the grade mark and any other mark, or any variations in such marks approved by the Administrator and authorized to be affixed to any product, or affixed to or printed on the packaging material of any product, stating that the product was graded, or indicating the appropriate U. S. grade or condition of the product, or for the purpose of maintaining

the identity of products graded under these regulations.

Official identification means any United States standard designation of class, grade, quality, size, quantity, or condition specified in these regulations or any symbol, stamp, label or seal indicating that the product has been officially graded and/or indicating the class, grade, quality, size, quantity, or condition of the product approved by the Administrator and authorized to be affixed to any product, or affixed to or printed on the packaging material of any product.

Official device means a stamping appliance, branding device, stencil, printed label, or any other mechanically or manually operated tool that is approved by the Administrator for the purpose of applying any official mark or other identification to any product or the packaging material thereof.

Administration

The Administrator shall perform, for and under the supervision of the Secretary, such duties as the Secretary may require in the enforcement or administration of the provisions of the act. The Administrator is authorized to waive for limited periods any particular provisions of the regulations to permit experimentation so that new procedures, equipment, and processing techniques may be tested to facilitate definite improvements and at the same time to determine full compliance with the spirit and intent of the regulations.

Basis of grading service.

Any grading service in accordance with these regulations shall be for class, quality, quantity, or condition or any combination thereof. Grading service with respect to the determination of the quality of products shall be on the basis of the "United States Standards, Grades, and Weight Classes" as contained herein. However, grading service may be rendered with respect to products which are bought and sold on the basis of institutional contract specifications or specifications of the applicant and such service, when approved by the Administrator, shall be rendered on the basis of such specifications. The supervision of packaging shall be in accordance with such instructions as may be approved or issued by the Administrator.

Unless otherwise approved by the area supervisor, continuous grading service in an official plant may be rendered only when a majority of the grader's time each month is utilized in performing grading for quality on the basis of the United States Standards set forth herein.

Whenever grading service is performed on a representative sample basis, such sample shall be drawn and consist of not less than the minimum number of cases as indicated in the following table. A minimum of one hundred eggs shall be examined per sample case. For lots which consist of less than 1 case, a minimum of 50 eggs shall be examined. If the lot consists of less than 50 eggs, all eggs will be examined.

Table 9. Minimum Number of Cases Comprising a Representative Sample

Cases in lot:	Cases in sample:	Cases in lot:	Cases in sample:
1 case	1	101 to 200, inclusive	8
2 to 10, inclusive	2	201 to 300, inclusive	11
11 to 25, inclusive	3	301 to 400, inclusive	13
26 to 50, inclusive	4	401 to 500, inclusive	14
51 to 100, inclusive	5	501 to 600, inclusive	16

For each additional 50 cases, or fraction thereof, in excess of 600 cases, one additional case shall be included in the sample.

Accessibility and condition of product. Each product for which grading service is requested shall be so conditioned and placed as to permit a proper determination of the class, quality, quantity, or condition of such product.

Supervision

All grading service shall be subject to supervision at all times by the applicable State supervisor, circuit supervisor, area supervisor, and national supervisor. Such service shall be rendered where the facilities and conditions are satisfactory for the conduct of the service and the requisite graders and samplers are available. Whenever the supervisor of a grader has evidence that such grader incorrectly graded a product, such supervisor shall take such action as is necessary to correct the grading and to cause any improper grade marks which appear on the product or the containers thereof to be corrected prior to shipment of the product from the place of initial grading.

Licensed Graders, Samplers, and Supervisors of Packaging. Except as otherwise provided in paragraph (c) of this section, any person, who is a Federal or State employee possessing proper qualifications as determined by an examination for competency, and who is to perform grading service, may be licensed by the Secretary as a grader.

All licenses issued by the Secretary shall be countersigned by the officer in charge of the poultry grading service of the Consumer and Marketing Service or any other designated officer of such Service.

No person may be licensed to grade or sample any product in which he is financially interested.

Authorization to perform limited grading services. Any person who is employed by any official plant and possesses proper qualifications, as determined by the Administrator, may be authorized to candle and grade eggs on the basis of the "United States Standards for Quality of Individual Shell Eggs," with respect to eggs purchased from producers or eggs to be packaged with official identification. In addition, such authorization may be granted to any qualified person to act as a "supervisor of packing" in the packaging and grade labeling of products. No person to whom such authorization is granted shall have authority to issue any grading certificates, grading memoranda, or other official documents; and all eggs which are graded by any such person shall thereafter be check graded by a grader. Each authorization shall be signed by the grader who determined the qualifications of the person authorized to perform such limited grading services. When the employee of an official plant ceases to perform such limited grading services at the plant, his authorization shall be automatically canceled.

Suspension of license or authority; revocation. When no appeal is filed within the prescribed 7 days after receiving notice of suspension of license, the license or authority to perform limited grading services is revoked.

Cancellation of license. Upon termination of his services as a grader, sampler, or supervisor of packaging, each licensee shall surrender his license immediately for cancellation.

Political activity. All graders and samplers are forbidden during the period of their respective appointments or licenses, to take an active part in political management or in political campaigns.

Identification. All graders, samplers, and supervisors of packaging shall each have in possession at all times, and present upon request, while on duty, the means of identification furnished by the Department of such person.

Facilities and equipment for graders

Facilities and equipment to be furnished by the applicant for use of graders in performing service on a resident basis shall include (when deemed necessary) the following: (1) An accurate metal stem thermometer; (2) scales to weigh individual eggs, cartons of eggs, and bulk eggs. Test weights for each type scale used; (3) an acceptable candling light.

Furnished office space, a desk (equipped with a satisfactory locking device), and lockers or cabinets suitable for the protection and storage of official stamps and supplies. Such space and equipment must meet the approval of the National Supervisor.

For packing Grade AA and Grade A eggs, an approved room or separate area for the breakout, adequate lighting, facilities for washing equipment, a breakout table, and a micrometer.

Application for grading and sampling

An application for grading or sampling service may be made by any interested person, including, but not being limited to, the United States, any State, county, municipality, or common carrier, and any authorized agent of the foregoing.

Noncontinuous grading service on a fee basis. An application for any noncontinuous grading service on a fee basis may be made in any office of grading, or with any grader or sampler at or nearest the place where the service is desired. Such application may be made orally (in person or by telephone), in writing, or by telegraph. If the application for grading service be made orally, the office of grading or the grader or sampler with whom such application is made, or the Administrator, may require that the application be confirmed in writing.

Continuous grading service on a resident basis or continuous grading service on a nonresident basis. An application for continuous grading service on a resident basis or for continuous grading service on a nonresident basis must be made in writing on forms approved by the Administrator. Such forms may be obtained at the national, area or state grading office. In making application, the applicant agrees to comply with the terms and conditions of the regulations (including, but not being limited to, such instructions governing grading of products as may be issued from time to time by the Administrator). No member of or Delegate to Congress or Resident Commissioner shall be admitted to any benefit that may arise from such service unless derived through service rendered a corporation for its general benefit.

An application for grading service or sampling service may be rejected by the Administrator.

Violations

Report of violations. Each grader, sampler and supervisor of packaging shall report in the manner prescribed by the Administrator, all violations and noncompliances under the act of which such grader, sampler or supervisor of packaging has knowledge.

Denial of service. The following acts or practices or the causing thereof may be deemed sufficient cause for the debarment, by the Administrator, of any person, including any agents, officers, subsidiaries or affliates of such persons, from any or all benefits of the act for a specified period, after notice and opportunity for hearing has been accorded him:

(1) Misrepresentation, deceptive, or fraudulent act or practice. Any wilful misrepresentation or any deceptive or fraudulent act or practice found to be made or committed by any person in connection with: (i) the making or filing of an application for any grading service or sampling service, appeal for grading service; (ii) the making of the product accessible for sampling or grading; (iii) the making, issuing or using or attempting to issue or use any grading certificate, symbol, stamp, label, seal, or identification authorized pursuant to the regulations in this part; (iv) the use of the terms "United States" or "U.S." in conjunction with the grade of the product; (v) the use of any of the aforesaid terms or any official stamp, symbol, label, seal, or identification in the labeling or advertising of any product; or (vi) the use of the terms "Government Grader," "Federal-State Graded," or terms of similar import in the labeling or advertising of any product.

(2) Use of facsimile forms. Using or attempting to use a form which simulates in whole or in part any certificate, symbol, stamp, label, seal or identification authorized to be issued or used under the regulations in this law.

(3) Willful violation of the regulations. Any willful violation of the regulations in this act.

(4) Interferring with a grader or employee of the Service. Any interference with or obstruction or any attempted interference or obstruction of or assault upon any grader, licensee, or employee of the Service in the performance of his duties. The giving or offering, directly or indirectly, of any money, loan, gift or anything of value to an employee of the

Service or the making or offering of any contribution to or in any way supplementing the salary, compensation or expenses of an employee of the Service or the offering or entering into a private contract or agreement with an employee of the Service for any services to be rendered while employed by the Service.

(5) Misleading labeling. The use of the terms "Government Graded," "Federal-State Graded," or terms of similar import in the labeling or advertising of any product without stating in the label or advertisement the U.S. grade of the product as determined by an authorized grader.

(6) Miscellaneous. The existence of any of the conditions constituting the basis for the rejection of an application for grading service.

Whenever the Administrator has reason to believe that any person, or his employee, agent, or representative has flagrantly or repeatedly committed any of the acts or practices specified in paragraph (a) above, he may without hearing direct that the benefits of the act be denied such person, including any agents, officers, subsidiaries or affiliates of such person, pending investigation and hearing and shall give notice thereof by registered mail. A written petition for reconsideration of such interim denial may be filed with the Administrator by any person so denied the benefits of the act if postmarked or delivered within 10 days after notice of the interim denial. Such petition shall state specifically the errors alleged to have been made by the Administrator in denying the benefits of the act pending investigation and hearing. Within 20 days following the receipt of such a petition for reconsideration, the Administrator shall reinstate the benefits of the act or notify the petitioner by registered mail of the reasons for continued interim denial.

Identifying and Marking Products

Authority to use official identification. Authority to officially identify product, graded according to these regulations, is granted only to applicants who make the services of a grader or supervisor of packaging available for use in accordance with these regulations.

Approval of official identification. Any label or packaging material which bears any official identification shall be used only in such manner as the Administrator may prescribe. No label or packaging material bearing official identification may be used unless finished copies or samples of such labels and packaging material have been approved by the Administrator, except that a grader may apply official identification stamps to shipping containers if they do not bear any statement that is false or misleading. No label bearing the official identification shall be printed for use until the printer's final proof has been approved by the Administrator; and no label bearing any official identification shall be used until finished copies or samples of such label have been approved by the Administrator. A label which bears official identification shall not bear any statement that is false or misleading. If the label be printed or otherwise applied directly to the container, the principal display panels of such container shall for this purpose be considered as the label. The label shall contain the name and address of the packer or distributor of the product, the name of the product and a statement of the net contents of the container.

Information required on grademark. Except as otherwise authorized, each grademark provided for in these regulations shall conspicuously and legibly indicate the letters "USDA" and the U.S. grade of the product it identifies such as "A Grade" (illustrated in Figure 6).

The size or weight class of the product such as "Large" and such terms as "Federal-State Graded" or words of similar import may be shown within the grademark (illustrated in Figure 7). However, such terms as "Federal-State Graded" need not be shown. The size or weight class of the product may be omitted from the grademark provided it appears prominently on the main panel of the carton.

The plant number of the official plant preceded by the letter "P" may appear in the grademark. When not shown within the grademark, the plant identification must be shown elsewhere on the packaging material.

Form of official identification symbol and grade mark.

The shield set forth in Figure 5 shall be the official identification symbol for purposes of these regulations, and when used, imitated, or simulated in any manner in connection with shell eggs shall be deemed to constitute a representation that the product has been officially graded.

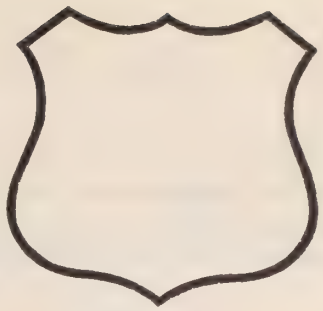

Figure 5

Except as otherwise authorized, the grademark permitted to be used to officially identify cartons of shell eggs which are graded pursuant to these regulations shall be contained in a shield and in the form and design indicated in Figures 6, 7, and 10. The shield shall be of sufficient size so that the print and other information contained therein be distinctly legible and in approximately the same proportion and size as shown in Figures 6 and 7. The grademark shall be printed on the carton or on a tape used to seal the carton. Existing supplies of cartons or tape bearing the grademark may be used until July 1, 1969.

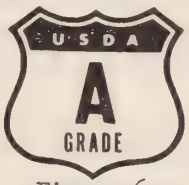

Figure 6

Figure 7

Fresh Fancy Quality or AA grademark. Eggs of this grade which are packaged and are to be grade marked shall be labeled with one of the grademarks as shown in Figures 8, 9, or 10.

Alternate Grade A mark: Eggs of this grade which are packaged and are to be grade marked shall be labeled with the grademark shown in Figures 6, 7, or 11.

Figure 11

Figure 8

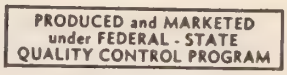

Figure 9

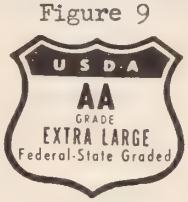

Figure 10

Dating of officially identified product

Each carton identified with grademarks shown in Figures 6, 7, and 10 shall have either (a) the date the eggs were graded; (b) an expiration date; or (c) a combination of the grading date and the expiration date, applied legibly to the carton or on the tape used to seal the carton.

If the date of grading be used, it shall be expressed as the "month" and "day," (i.e., 4-3), or as the consecutive day of the year. Cartons may be dated a maximum of 6 days later than when the first eggs in the shipment were packed. The shipment must be officially graded on the date which is shown on the cartons.

If the expiration date be used, it shall be stated as the "month" and "day," or the number of the "month" and "day" (i.e., 4-3), preceded by the letters "EXP." or a statement such as "Not To Be Sold After". The maximum expiration date permitted is 14 days. The first day is considered to be the date the first eggs in the shipment are packed. The eggs must be officially graded at the origin plant prior to shipment.

A combination of the date of grading and the expiration date may be used. The date of grading is when the first eggs in the shipment are packed. The expiration date shall be no more than 14 days later than the date of grading. The eggs must be officially graded at the origin

plant prior to shipment.

Any additional codes may be used only upon written approval of the administrator.

Rescindment of approved labels

Once a year, or more often, if requested, each applicant shall submit to the Administrator a list, in triplicate, of the approved labels which bear any official identification that have become obsolete, accompanied with a statement that such approvals are no longer desired. The approvals shall be identified by the date of approval, and the grade, weight class, and brand name of the product.

Prerequisites to Packaging Shell Eggs Identified with Consumer Grade Marks

Supervisor of packaging required. The official identification of any graded product shall be done only under the supervision of a grader or supervisor of packaging. The grader or supervisor of packaging shall have supervision over the use and handling of all material bearing any official identification.

Grading requirements of shell eggs identified with consumer grademarks. Shell eggs to be identified with the marks illustrated in Figures 6, 7, and 10 must be individually graded by a grader or by authorized personnel and thereafter check graded by a grader.

Shell eggs not graded in accordance with the above paragraph may be officially graded on a sample basis and the shipping containers may be identified with grademarks which contain the words "Sample Graded" and which are approved by the Administrator.

Shell eggs which are to bear the U.S. consumer grade mark shall be packed only from eggs of current production. They shall not possess any undesirable odors or flavors.

Requirements for eggs packaged under Fresh Fancy Quality grade mark or AA grade mark as shown in Figures 8, 9, and 10. Minimum requirements of procurement and distribution program. Each packing station or plant must have a satisfactory procurement and distribution program including, but not being limited to, the following requirements at the farm and retail store level as applicable:

Eggs from each flock shall be packed separately and the shipping cases marked so as to facilitate segregation at the packing station. A flock consists of birds not varying in age by more than 60 days. In operations with a continuous replacement procedure, such as in cage operations, birds shall be grouped together in accordance with the above requirements.

Eggs should be gathered from the nest at least twice, and preferably, three times a day.

Eggs which require cleaning should be cleaned in accordance with the applicable provisions herein. Eggs may be treated by oil dipping, oil spraying, or oil-emulsion spraying: Provided, that methods used be such as will not cause objectionable cloudiness in the whites. Oil treating and cleaning operations must be in compliance with the sanitary requirements as provided herein.

Eggs shall be cooled promptly after gathering to 60° F. or below and held at a reasonable constant temperature not to exceed 60° F. and at a relative humidity of approximately 70 percent. Notwithstanding the foregoing, the temperature of the eggs may rise to 70° F. during washing and packaging operations provided the eggs are moved promptly to a cooler or transported at a temperature of 60° F. or below.

Eggs shall be transported and handled under such conditions as will prevent sweating and at a temperature of 60° F. or below.

The temperature at which the eggs are held and displayed at the retail store shall not exceed 60° F.

Periodic checks to determine the adequacy of the production and distribution programs shall

be made by the governmentally employed graders.

Minimum requirements at packaging plant. (1) The quality factor of albumen firmness shall be determined by the broken-out score, measured in Haugh units, and the condition of the yolk shall be observed during such testing. The breakout test shall be made every other week unless the breakout records indicate a variation in individual eggs or averages beyond that normally expected for this program, in which case the breakout shall be made weekly. The test shall be accomplished at the assembly plant or at the farm in the event the eggs go directly from the farm to the store. Eggs which do not meet the requirements of AA quality with respect to shell texture or shape shall not be selected as part of any sample that is to be broken out and scored. Sampling, breakout testing, and maintenance of records of breakout test shall be done by or under the immediate supervision of a grader.

The internal temperature of the eggs shall not be lower than 45° F. or higher than 60° F. at the time of making the breakout test. Eggs shall be placed under refrigeration at a temperature not to exceed 60° F. and a relative humidity of approximately 70 percent promptly after packaging.

A flock may be eligible for entry under the program when a sample of 25 eggs drawn at random averages 76 Haugh units or higher; or when two samples of 25 eggs each drawn at random (one sample per week for two consecutive weeks) each averages 74 Haugh units* or higher. Notwithstanding the foregoing, a flock shall not be eligible if any sample contains more than one egg measuring less than 60 Haugh units, and the yolk of all eggs in the sample shall have a well-rounded appearance with a reasonably uniform color.

A flock may remain on the program: Provided, That (i) a moving average of 74 Haugh units or higher be maintained; (ii) that the yolks of all eggs have a well-rounded appearance with a reasonably uniform color; and (iii) that not more than one egg in any sample of 10 eggs or more measures less than 60 Haugh units.

The biweekly or weekly average shall be computed by averaging the results obtained when testing eggs in accordance with either subdivision (i) or (ii) below. Samples shall be drawn at random from each flock, from a single shipment, every 2 weeks (or weekly when required).

(i) A sample of 10 eggs shall be tested when the moving average is below 80 Haugh units and not more than one egg in the sample shall measure less than 60 Haugh units.

(ii) A sample of 5 eggs may be tested when the moving average is 80 Haugh units or above and the sample contains no eggs which measure less than 60 Haugh units. If only one egg measures less than 60 Haugh units, an additional 5 eggs shall be tested. If this second 5-egg sample contains no eggs below 60 Haugh units, the average of the 10 eggs shall be used in determining the biweekly or weekly average.

The moving average shall be computed by averaging the results of the latest 2 biweekly or 4 weekly (when required) Haugh unit entries of a flock.

Any flock which has been on the program and is excluded for failure to meet the requirements may be reinstated by the same procedures used to originally enter a flock on the program.

Eggs with clean, unbroken, practically normal shells from flocks which meet the provisions of this section may be packaged and officially labeled as Fresh Fancy Quality or U.S. Consumer Grade AA after the removal of eggs containing blood and meat spots and loss eggs.

Packages or sealing tapes shall bear in distinctly legible form a date, stated as the "month"

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* An accurate objective test of egg quality is based on the Haugh Units which are determined by using the weight of the egg and height of the thick albumin, as measured by a tripod micrometer after the egg has been broken out on a flat surface.

and "day," or the number of the "month" and "day" (i.e., 4-3), preceded by the letters "EXP." or a statement such as "Not To Be Sold After". The expiration date shall not exceed 10 days from the date the eggs are packed, excluding the day of pack. The eggs must be packed within 6 days from the time they are received at the plant (not counting the day received), or that shipment must be tested again for Haugh units and other factors to determine their eligibility for packing. Notwithstanding the foregoing, other systems of dating may be approved which accomplish the purposes of this paragraph, providing application for such a system be made in writing by the applicant and concurred in by the Administrator.

Graders shall examine samples of packaged product in accordance with these provisions or as determined by the National Supervisor. A tolerance of 5 percent is permitted in any combination of eggs that are of B quality or C quality with respect to shell, C quality with respect to meat or blood spots, and checks. Dirties, Leakers, and Loss are not permitted.

Requirements for eggs packaged under the U.S. Grade A mark as shown in Figure 11. Eggs packaged with the grade label designation specified in Figure 11 shall meet all of the provisions for this grade except for the following:

(a) A flock shall consist of birds located on the same farm and managed under identical supervision.

(b) A flock may be eligible for entry under the program when a sample of 25 eggs drawn at random averages 64 Haugh units or higher; or when two samples of 25 eggs each drawn at random (one sample per week for two consecutive weeks) each averages 62 Haugh units or higher. Notwithstanding the foregoing, a flock shall not be eligible if any sample contains more than four eggs measuring less than 60 Haugh units, and the yolk of all eggs in the sample shall have a well-rounded appearance with a reasonably uniform color.

(c) A flock may remain on the program: Provided, That (1) a moving average of 62 Haugh units or higher be maintained; (2) the yolks of all eggs have a well-rounded appearance with a reasonably uniform color; and (3) not more than two eggs in any sample of 10 eggs measure less than 60 Haugh units.

(d) The biweekly or weekly average shall be computed by averaging the results obtained by testing 10 eggs from each flock every other week (or weekly when required). Samples shall be drawn at random every other week (or weekly when required) from each flock from a single shipment. Notwithstanding the foregoing, 5 eggs may be used as the sample size when the moving average is such that the flock would qualify under the provisions for AA Grade eggs.

(e) A tolerance of 5 percent is permitted in any combination for C quality with respect to shell, meat or blood spots, and checks. Dirties, Leakers, and Loss are not permitted.

Fees and Charges

Fees and charges for any grading service shall be paid by the interested party making the application for such grading service, in accordance with the applicable provisions of these regulations, and, if so required by the grader or sampler, such fees and charges shall be paid in advance.

Minimum facility and operating requirements for shell egg grading and packing plants.

General requirements for buildings and plant facilities. These are in accordance with the sanitary requirements of food production plants.

Grading room requirements. The grading room shall be adequately darkened to make possible accurate quality determination of the candled appearance of eggs.

(1) There shall be no crossbeams of light, and light reflection from candling lights shall be kept at a minimum.

(2) Candling benches shall be constructed so as to permit cleaning and provide ample shelf space for convenient placement of the different grades to be packed.

(3) The candling lights shall be capable of delivering reasonably uniform intensity of light at the candling aperture to facilitate accurate quality determinations; and the light shall provide ample case light for detection of stained and dirty shells and the condition of the packing materials. In operations utilizing mechanical grading equipment, adequate light shall be provided to facilitate necessary quality determinations, including the detection and removal of stained and dirty shells and the condition of the packing material.

(4) Individual egg scales shall be provided to check accuracy of weight classing.

(5) Weighing equipment, whether manual or automatic, shall be kept reasonably clean and shall be capable of ready adjustment.

(6) Adequate ventilation shall be provided.

Cooler room requirements. (1) Cooler rooms shall have refrigeration facilities capable of reducing within 24 hours and holding the maximum volume of eggs handled to 60° F. or below. Accurate thermometers shall be provided.

(2) Cooler rooms shall be free from objectionable odors and from mold, and shall be maintained in a sanitary condition.

(3) All shell egg coolers shall be equipped with a hygrometer or portable equipment such as a psychrometer shall be available to determine the relative humidity. Humidifying equipment capable of maintaining a relative humidity which will minimize shrinkage shall be provided.

Shell egg protecting operations. Shell egg protecting (oil processing) operations shall be conducted in a manner to avoid contamination of the product and maximize conservation of its quality.

(1) Eggs with excess moisture on the shell shall not be shell protected.

(2) Oil having any off odor, or that is obviously contaminated, shall not be used in shell egg protection.

(3) Processing oil that has been previously used and which has become contaminated shall be filtered and heat treated at 180° F. for 3 minutes prior to use.

(4) Shell egg processing equipment shall be washed, rinsed, and treated with a bactericidal agent each time the oil is removed. It is preferable to filter and heat treat processing oil and clean processing equipment daily when in use.

(5) Adequate coverage and protection against dust and dirt shall be provided when the equipment is not in use.

Shell egg cleaning operations. (1) Shell egg cleaning equipment shall be kept in good repair and shall be cleaned after each day's use or more frequently if necessary.

(2) Waste water from the egg washing operation shall go directly to a drain.

(3) Continuous-type washers shall have a complete water change at least once during each shift and at the end of each shift, or more frequently if considered necessary.

(4) Wash water used shall be at least 20° F. warmer than the eggs. The minimum maintained temperature of the wash water shall be 90° F. The 20 degree differential shall be maintained throughout the cleaning cycle. Prewetting by submersion shall not exceed five (5) minutes.

(5) During any rest period, eggs shall be removed from the washing and rinsing area of the egg washer and from the scanning area whenever there is a build-up of heat.

(6) Only approved cleaning and sanitizing compounds may be used. The use of metered equipment for dispensing the compounds into solution is recommended.

(7) The entire shell egg cleaning and drying operation shall be continuous and shall be completed as rapidly as possible.

(8) Only potable water may be used to wash eggs. Each official plant shall submit certification to the national office stating that their water supply is potable. An analysis of the iron content of the water supply, stated in parts per million, is also required.

(9) Potable water or rinse water overflow shall be added continuously to recirculated wash water for inline-type washers so as to provide for a continuous overflow. When the equipment, other than inline-type washers, has no continuous intake and overflow, the wash water shall be replaced after each basket or container of eggs is washed.

(10) All washed eggs shall be spray rinsed with warm, potable water which contains an approved sanitizing compound.

(11) Washed eggs shall be reasonably dry before cartoning or casing.

(12) When steam or vapors originate from the washing operation, they shall be continuously and directly removed to the outside of the building.

Requirements for eggs which are to be marked with official U.S. identification mark. (1) Shell eggs, except as otherwise provided for under Grade AA and Grade A and those graded from commercial cold storages, shall not be below 40° F. or above 70° F. at the time of

official grading. Eggs held in a plant shall be placed under refrigeration of 60° F. or below promptly after packaging.

(2) Every reasonable precaution shall be exercised to prevent "sweating" of eggs.

(3) Eggs which are to be officially identified with consumer or procurement grademarks shall be packaged only in new or good used cases and packing materials. Cases and packing materials must be reasonably clean, free of mold, mustiness and off odors and must be of sufficient strength and durability to adequately protect the eggs during normal distribution.

Pesticides, insecticides, and rodenticides used in the plant shall be approved and shall be handled in accordance with the manufacturers' instructions.

Health and hygiene of personnel: Same as for other food producing plants.

United States Standards for Quality of Individual Shell Eggs

The United States standards for quality of individual shell eggs contained in this subpart are applicable only to eggs that are the product of the domesticated chicken hen and are in the shell.

Interior egg quality specifications for these standards are based on the apparent condition of the interior contents of the egg as it is twirled before the candling light, except as otherwise provided. Any type or make of candling light may be used that will enable the particular grader to make consistently accurate determination of the interior quality of shell eggs. It is desirable to break out an occasional egg and by determining the Haugh unit value of the broken-out egg, compare the broken-out and candled appearance, thereby aiding in correlating candled and broken-out appearance.

AA Quality: The shell must be clean, unbroken, and practically normal. The air cell must not exceed 1/8 inch in depth and be practically regular. The white must be clear and firm so that the yolk is only slightly defined when the egg is twirled before the candling light. The yolk must be practically free from apparent defects.

A Quality: The shell must be clean, unbroken, and practically normal. The air cell must not exceed 3/16 inch in depth and must be practically regular. The white must be clear and at least reasonably firm so that the yolk outline is only fairly well defined when the egg is twirled before the candling light. The yolk must be practically free from apparent defects.

B Quality: The shell must be unbroken and may be slightly abnormal and may show slight stains but no adhering dirt, Provided, That they do not appreciably detract from the appearance of the egg. When the stain is localized, approximately 1/32 of the shell surface may be slightly stained, and when the slightly stained areas are scattered, approximately 1/16 of the shell surface may be slightly stained. The air cell must not exceed 3/8 inch in depth, may show unlimited movement, and may be free or bubbly. The white must be clear and may be slightly weak so that the yolk outline is well defined when the egg is twirled before the candling light. The yolk may appear slightly enlarged and slightly flattened and may show other definite, but not serious, defects.

C Quality: The shell must be unbroken, may be abnormal and may have slightly stained areas. Moderately stained areas are permitted if they do not cover more than 1/4 of the shell surface. Eggs having shells with prominent stains or adhering dirt are not permitted. The air cell may be over 3/8 inch in depth and may be free or bubbly. The white may be weak and watery so that the yolk outline is plainly visible when the egg is twirled before the candling light. The yolk may appear dark, enlarged, and flattened, and may show clearly visible germ development but no blood due to such development. It may show other serious defects that do not render the egg inedible. Small blood clots or spots (aggregating not more than 1/8 inch in diameter) may be present.

Dirty: The shell must be unbroken and it has adhering dirt or foreign material, prominent stains, or moderate stains covering more than one-fourth of the shell surface.

Check: An individual egg that has a broken shell or crack in the shell but with its shell membranes intact and its contents do not leak. A "check" is considered to be lower in quality

than a "dirty".

Terms descriptive of shell

Clean. A shell that is free from foreign material and from stains or discolorations that are readily visible. An egg may be considered clean if it has only very small specks or stains, if such specks or stains are not of sufficient number or intensity to detract from the generally clean appearance of the egg. Eggs that show traces of processing oil on the shell are considered clean unless otherwise soiled.

Dirty. A shell which has dirt or foreign material adhering to its surface, which has prominent stains, or has moderate stains covering more than one-fourth of the shell surface.

Practically normal (AA or A quality). A shell that approximates the usual shape and that is of good even texture and strength and is free from rough areas or thin spots. Slight ridges and rough areas that do not materially affect the shape, texture, and strength of the shell are permitted.

Slightly abnormal (B quality). A shell that may be somewhat unusual in shape or that may be slightly faulty in texture or strength. It may show definite ridges but no pronounced thin spots or rough areas.

Abnormal (C quality). A shell that may be decidedly misshapen or faulty in texture or strength or that may show pronounced ridges, thin spots, or rough areas.

Terms descriptive of the air cell

Depth of air cell (air space between shell membranes, normally in the large end of the egg). The depth of the air cell is the distance from its top to its bottom when the egg is held air cell upward.

Practically regular (AA or A quality). An air cell that maintains a practically fixed position in the egg and shows a fairly even outline with not more than 2/8-inch movement in any direction as the egg is rotated.

Free air cell (B or C quality). An air cell that moves freely toward the uppermost point in the egg as the egg is rotated slowly.

Bubbly air cell (B or C quality). A ruptured air cell resulting in one or more small separate air bubbles usually floating beneath the main air cell.

Terms descriptive of the white

Clear. A white that is free from discolorations or from any foreign bodies floating in it. (Prominent chalazas should not be confused with foreign bodies such as spots or blood clots.)

Firm (AA quality). A white that is sufficiently thick or viscous to prevent the yolk outline from being more than slightly defined or indistinctly indicated when the egg is twirled. With respect to a broken-out egg, a firm white has a Haugh unit value of 72 or higher when measured at a temperature between 45° and 60° F.

Reasonably firm (A quality). A white that is somewhat less thick or viscous than a firm white. A reasonably firm white permits the yolk to approach the shell more closely which results in a fairly well defined yolk outline when the egg is twirled. With respect to a broken-out egg, a reasonably firm white has a Haugh unit value of 60 to 72 when measured at a temperature between 45° and 60° F.

Slightly weak (B quality). A white that is lacking in thickness or viscosity to an extent that causes the yolk outline to appear well defined when the egg is twirled. With respect to a broken-out egg, a slightly weak white has a Haugh unit value of 31 to 60 when measured at a temperature between 45° and 60° F.

Weak and watery (C quality). A white that is thin and generally lacking in viscosity. A weak

and watery white permits the yolk to approach the shell closely, thus causing the yolk outline to appear plainly visible and dark when the egg is twirled. With respect to a broken-out egg, a weak and watery white has a Haugh unit value lower than 31 when measured at a temperature between 45° and 60° F.

Blood clots and spots (not due to germ development). Blood clots or spots on the surface of the yolk or floating in the white. These blood clots may have lost their characteristic red color and appear as small spots or foreign material commonly referred to as meat spots. If they be small (aggregating not more than 1/8 inch in diameter), the egg may be classed as "C Quality". If larger, or showing diffusion of blood in the white surrounding them, the egg shall be classified as loss.

Bloody white. An egg, the white of which has blood diffused through it. Such a condition may be present in newlaid eggs. Eggs with bloody whites are classed as loss.

Terms descriptive of the yolk

Outline slightly defined (AA quality). A yolk outline that is indistinctly indicated and appears to blend into the surrounding white as the egg is twirled.

Outline fairly well defined (A quality). A yolk outline that is discernible but not clearly outlined as the egg is twirled.

Outline well defined (B quality). A yolk outline that is quite definite and distinct as the egg is twirled.

Outline plainly visible (C quality). A yolk outline that is clearly visible as a dark shadow when the egg is twirled.

Slightly enlarged and slightly flattened (B quality). A yolk in which the yolk membranes and tissues have weakened somewhat causing it to appear slightly enlarged and slightly flattened.

Enlarged and flattened (C quality). A yolk in which the yolk membranes and tissues have weakened and moisture has been absorbed from the white to such an extent that it appears definitely enlarged and flat.

Practically free from defects (AA or A quality). A yolk that shows no germ development but may show other very slight defects on its surface.

Definite but not serious defects (B quality). A yolk that may show definite spots or areas on its surface but with only slight indication of germ development or other pronounced or serious defects.

Other serious defects (C quality). A yolk that shows well developed spots or areas and other serious defects, such as olive yolks, which do not render the egg inedible.

Clearly visible germ development (C quality). A development of the germ spot on the yolk of a fertile egg that has progressed to a point where it is plainly visible as a definite circular area or spot with no blood in evidence.

Blood due to germ development. Blood caused by development of the germ in a fertile egg to the point where it is visible as definite lines or as a blood ring. Such an egg is classified as inedible.

General items

Loss. An egg that is inedible, smashed, or broken so that contents are leaking, cooked, frozen, contaminated, or containing bloody whites, large blood spots, large unsightly meat spots, or other foreign material.

Inedible eggs. Eggs of the following descriptions are classed as inedible: black rots, yellow rots, white rots, mixed rots (addled eggs), sour eggs, eggs with green whites, eggs

with stuck yolks, moldly eggs, musty eggs, eggs showing blood rings, eggs containing embryo chicks at or beyond the blood ring stage), and any eggs that are adulterated as such term is defined pursuant to the Federal Food, Drug, and Cosmetic Act.

Leaker. An individual egg that has a crack or break in the shell and shell membranes to the extent that the egg contents are exuding or free to exude through the shell.

United States Grades and Weight Classes for Shell Eggs

These grades are applicable to edible shell eggs in "lot" quantities rather than on an "individual" egg basis. A lot may contain any quantity of two or more eggs. Reference in these standards to the term "case" means 30-dozen egg cases as used in commercial practices in the United States. The size of the sample used to determine grade shall be on the basis of the requirements as stated in the law or as determined by the National Supervisor.

Terms which are defined in the United States standards for quality of individual shell eggs have the same meaning here as in those standards.

Aggregate tolerances are permitted within each grade only as an allowance for variable efficiency and interpretation of graders, normal changes under favorable conditions during reasonable periods between grading, and reasonable variation of graders' interpretation.

Substitution of higher qualities for the lower qualities specified is permitted.

The percentage requirements for grades as set forth below are applicable except that interior quality factors shall be determined in accordance with the requirements for AA Grade and A Grade when the lot is labeled "Produced and Marketed under Federal-State Quality Control Program".

"No grade" means eggs of possible edible quality that fail to meet the requirements of an official U.S. Grade or that have been contaminated by smoke, chemicals, or other foreign material which has seriously affected the character, appearance, or flavor of the eggs.

United States Consumer Grades and Weight Classes for Shell Eggs

Fresh Fancy Quality shall consist of eggs meeting the AA Grade requirements.

U.S. Grade AA: U.S. Consumer Grade AA (at origin) shall consist of eggs which are 85 percent AA quality. Within the maximum tolerance of 15 percent which may be below AA quality, not more than 5 percent may be B quality, C quality, or Checks in any combination. No Dirties or Loss are permitted. This grade is also applicable when the lot consists of eggs meeting the AA Grade requirements. (Table 10)

U.S. Consumer Grade AA (destination) shall consist of eggs which are 80 percent AA quality. Within the maximum tolerance of 20 percent which may be below AA quality, not more than 5 percent may be B quality, C quality, or Checks in any combination, and not more than 0.5 percent Leakers or Dirties in any combination. This grade is also applicable when the lot consists of eggs meeting the AA Grade requirements. (Table 10.)

U.S. Grade A: U.S. Consumer Grade A (at origin) shall consist of eggs which are 85 percent A quality or better. Within the maximum tolerance of 15 percent which may be below A quality, not more than 5 percent may be C quality or Checks in any combination. No Dirties or Loss are permitted. This grade is also applicable when the lot consists of eggs meeting the A Grade requirements. (Table 10)

U.S. Consumer Grade A (destination) shall consist of eggs which are 80 percent A quality or better. Within the maximum tolerance of 20 percent which may be below A quality, not more than 5 percent may be C quality or Checks in any combination, and not more than 0.5 percent Leakers or Dirties in any combination. This grade is also applicable when the lot consists of eggs meeting the Grade A requirements. (Table 10)

U.S. Grade B: U.S. Consumer Grade B (at origin) shall consist of eggs which are 85 percent B quality or better. Within the maximum tolerance of 15 percent which may be below B quality, not more than 10 percent may be Checks. No Dirties or Loss are permitted. (Table 10)

U.S. Consumer Grade B (destination) shall consist of eggs which are 80 percent B quality or better. Within the maximum tolerance of 20 percent which may be below B quality, not more than 10 percent may be Checks, and not more than 0.5 percent Leakers or Dirties in any combination. (Table 10)

Additional tolerances: In lots of two or more cases:

(i) For Grade AA - no individual case may exceed 10 percent less AA quality eggs than the minimum permitted for the lot average.

(ii) For Grade A - no individual case may exceed 10 percent less A quality eggs than the minimum permitted for the lot average.

(iii) For Grade B - no individual case may exceed 10 percent less B quality eggs than the minimum permitted for the lot average.

In lots of two or more cartons, no individual carton may contain less than eight eggs of the specified quality and no individual carton may contain less than 10 eggs of the specified quality and the next lower quality. The remaining two eggs may consist of a combination of qualities below the next lower quality (i.e., in lots of Grade A, not more than two eggs of the qualities in individual cartons within the sample may be C or Checks).

Table 10 - Summary of U. S. Consumer Grades for Shell Eggs

U.S. Consumer grade (origin)	Quality required *	Tolerance permitted	
		Percent	Quality
Grade AA or Fresh Fancy Quality --	85 percent AA ----------	Up to 15 ------	A.
		Not over 5 ----	B,C, or Check
Grade A ----------	85 percent A or better -----	Up to 15 ------	B.
		Not over 5 ----	C or Check
Grade B ----------	85 percent B or better -----	Up to 15 ------	C.
		Not over 10 ---	Checks.
U.S. Consumer grade (destination)	Quality required*	Tolerance permitted	
		Percent	Quality
Grade AA or Fresh Franch Quality--	80 percent AA ----------	Up to 20 -----	A.
		Not over 5 ---	B,C,or Check
		Not over 0.5--	Leakers or Dirties.
Grade A ----------	80 percent A or better -----	Up to 20------	B.
		Not over 5----	C or Check
		Not over 0.5--	Leakers or Dirties.
Grade B ----------	80 percent B or better -----	Up to 20------	C.
		Not over 10---	Checks.
		Not over 0.5--	Leakers or

* In lots of two or more cases or cartons, see Table 11 of this section for tolerances for an individual case or carton within a lot.

Table 11 - Tolerance for Individual Case or Carton Within A Lot

U.S. Consumer grade	Case-minimum quality	Origin	Destination	Carton-minimum quality -number of eggs (origin and destination)
		Percent	Percent	
Grade AA or Fresh Fancy Quality ----------	AA----------	75	70	8 eggs AA.
	A----------	15	20	2 eggs A.
	B,C,or Check----	10	10	2 eggs B,C, or Check.
Grade A ----------	A----------	75	70	8 eggs A.
	B----------	15	20	2 eggs B.
	C or Check------	10	10	2 eggs C or Check.
Grade B ----------	B----------	75	70	8 eggs B.
	C----------	5	10	2 eggs C.
	Check----------	20	20	2 eggs Check.

Weight classes

The weight classes for U.S. Consumer Grades for Shell Eggs shall be as indicated in Table 12 and shall apply to all consumer grades.

A lot average tolerance of 3.3 percent for individual eggs in the next lower weight class is permitted as long as no individual case within the lot exceeds 5 percent.

Table 12. U.S. Weight Classes for Consumer Grades for Shell Eggs

Size or weight class	Minimum net weight per dozen	Minimum net weight per 30 dozen	Minimum weight for individual eggs at rate per dozen
	Ounces	Pounds	Ounces
Jumbo	30	56	29
Extra large	27	50 1/2	26
Large	24	45	23
Medium	21	39 1/2	20
Small	18	34	17
Peewee	15	28	--

United States Procurement Grades and Weight Classes for Shell Eggs

Table 13 - Summary of U. S. Procurement Grades for Shell Eggs

U.S. Procurement Grade (origin)	A quality or better (lot average) at least[1]	Maximum tolerance permitted* (lot average)	
		Percent	Quality
	Percent		
I----------	85	Up to 15----------	B.
		Not over 5----------	C, Dirty, Check, Leaker and Loss.
II----------	65	Up to 35----------	B.
		Not over 10----------	C, Dirty, Check, Leaker, and Loss.

U.S. Procurement Grate (destination)	A quality or better (lot average) at least[1]	Maximum tolerance permitted** (lot average)	
		Percent	Quality
	Percent		
I----------	80	Up to 20 ----------	B.
		Not over 5----------	C, Dirty, Check, Leaker, and Loss.
II----------	60	Up to 40----------	B.
		Not over 10----------	C, Dirty, Check, Leaker, and Loss.

*Individual cases may not exceed 10 percent less A quality eggs than permitted for the lot average.

**Within each tolerance for qualities below B, the grades may contain no more than 3 percent Checks, and a combined total of three-tenths percent Dirties, Leakers, and Loss. Loss other than meat and blood spots shall not exceed 0.15 percent at origin and 0.20 percent at destination.

Table 14. Weight Classes for United States Procurement Grades

Weight classes	Average net weight on lot basis 30-dozen case	Minimum net weight individual 30-dozen case	Minimum net weight of individual eggs at rate per dozen	Maximum average percent of individual eggs below minimum weight lot average*
	Pounds	Pounds	Ounces	Percent
Extra large	50.5	50	26	3.33
Large	45	44.5	23	3.33
Medium	39.5	39	20	3.33
Small	34	33.5	17	3.33

*Individual cases may contain not over 10 percent of individual eggs below minimum weights specified in any weight class but such eggs shall weigh not less than the minimum specified for the next lower weight class.

U.S. Procurement Grade I (at origin) shall consist of eggs which are 85 percent A quality or better. Within the maximum of 15 percent which may be below A quality, not more than 5 percent may be of the qualities below B. The maximum tolerance of 5 percent may consist of C quality, not more than 3 percent Checks, and not more than 0.30 percent Dirties, Leakers, and Loss combined. Loss, other than meat and blood spots, shall not exceed 0.15 percent. (Table 13)

U.S. Procurement Grade I (destination) shall consist of eggs which are 80 percent A quality or better. Within the maximum of 20 percent which may be below A quality, not more than 5 percent may be of qualities below B. The maximum tolerance of 5 percent may consist of C quality, not more than 3 percent Checks, and not more than 0.30 percent Dirties, Leakers, and Loss combined. Loss, other than meat and blood spots shall not exceed 0.20 percent. (Table 13)

U.S. Procurement Grade II (at origin) shall consist of eggs which are 65 percent A quality or better. Within the maximum of 35 percent which may be below A quality, not more than 10 percent may be of the qualities below B. The maximum tolerance of 10 percent may consist of C quality, not more than 3 percent Checks, and not more than 0.30 percent Dirties, Leakers, and Loss combined. Loss, other than meat and blood spots, shall not exceed 0.15 percent. (Table 13)

U.S. Procurement Grade II (destination) shall consist of eggs which are 60 percent A quality or better. Within the maximum of 40 percent which may be below A quality, not more than 10 percent may be of the qualities below B. The maximum tolerance of 10 percent may consist of C quality, not more than 3 percent Checks, and not more than 0.30 percent Dirties, Leakers, and Loss combined. Loss, other than meat and blood spots, shall not exceed 0.20 percent. (Table 13)

Individual cases may contain not over 10 percent less A quality eggs than specified for the procurement grade.

The weight classes for United States Procurement Grades for Shell Eggs shall be as indicated in Table 14 and shall apply to all procurement grades.

United States Wholesale Grades and Weight Classes for Shell Eggs

"U.S. Specials % AA Quality" shall consist of eggs of which at least 20 percent are AA Quality; and the actual percentage of AA Quality eggs shall be stated in the grade name. Within the maximum of 80 percent which may be below AA Quality, not more than 7.5 percent may be B Quality, C Quality, Dirties or Checks in any combination and not more than 2.0 percent may be Loss. (Table 15)

"U.S. Extras % A Quality" shall consist of eggs of which at least 20 percent are not less

than A Quality; and the actual total percentage of A Quality and better quality eggs shall be stated in the grade name. Within the maximum of 80 percent which may be below A Quality, not more than 11.7 percent may be C Quality, Dirties, or Checks in any combination, and not more than 3.0 percent may be Loss. (Table 15)

"U.S. Standards % B Quality" shall consist of eggs of which at least 20 percent are not less than B Quality; and the actual total percentage of B Quality and better quality eggs shall be stated in the grade name. Within the maximum of 80 percent which may be below B Quality not more than 11.7 percent may be Dirties or Checks in any combination, and not more than 4 percent may be Loss. (Table 15)

"U.S. Trades % C Quality" shall consist of eggs of which at least 83.3 percent are not less than C Quality; and the actual total percentage of C Quality and better quality eggs shall be stated in the grade name. Within the maximum of 16.7 percent which may be Dirties or Checks in any combination and not more than 5 percent may be Loss. (Table 15)

"U.S. Dirties" shall consist of eggs that are Dirty and shall contain not more than 11.7 percent Checks and not more than 5 percent Loss. (Table 15)

"U.S. Checks" shall consist of eggs that are Checks and shall contain not more than 5 percent Loss. (Table 15)

The weight classes for the United States Wholesale Grades for Shell Eggs shall be as indicated in Table 16, and subject to the stated tolerance of 10 percent, shall apply to all wholesale grades except U.S. Dirties and U.S. Checks. There are no weight classes for U.S. Dirties or U.S. Checks.

Table 15. Summary of United States Wholesale Grades for Shell Eggs

Wholesale grade designation	Minimum percentage of eggs of specific qualities required*				Maximum tolerance permitted (lot average)				
	AA Quality	A Quality or better	B Quality or better	C Quality or better	B Quality, C Quality, Dirties and Checks	C Quality, Dirties and Checks	Dirties and Checks	Checks	Loss
U.S. Specials __% AA Quality**	20	Balance.	None permitted except for tolerances.		Percent 7.5	Percent	Percent	Percent	Percent 2
U.S. Extras __% A Quality**		20	Balance.	None permitted except for tolerances		11.7			3
U.S. Standards __% B Quality**			20	Balance			11.7		4
U.S. Trades __% C Quality**				83.3			11.7		5
U.S. Dirties __%								11.7	5
U.S. Checks __%									5

*Substitution of eggs possessing higher qualities for those possessing lower specified qualities is permitted.

**The actual total percentage must be stated in the grade name.

Table 16. Weight Classes for United States Wholesale Grades for Shell Eggs

Per 30 dozen eggs			Weights for individual eggs at rate per dozen	
Weight classes	Average net weight on a lot* basis	Minimum net weight individual case** basis	Minimum weight	Weight variation tolerance for not more than 10 percent, by count, of individual eggs.
	At least -			
Extra large	50 1/2 pounds	50 pounds	26 ounces	Under 26 but not under 24 ounces
Large	45 pounds	44 pounds	23 ounces	Under 23 but not under 21 ounces
Medium	39 1/2 pounds	39 pounds	20 ounces	Under 20 but not under 18 ounces
Small	34 pounds	None	None	None

*Lot means any quantity of 30 dozen or more eggs.
**Case means standard 30 dozen egg case as used in commercial practice in the U.S.

Table 17. United States Department of Agriculture
Consumer and Marketing Service, Poultry Division

Summary of United States Standards for Quality of Individual Shell Eggs Specifications for Each Quality Factor				
Quality Factor	AA Quality	A Quality	B Quality	C Quality
Shell	Clean. Unbroken. Practically normal.	Clean. Unbroken. Practically normal.	Clean; to slightly stained. Unbroken. May be slightly abnormal.	Clean; to moderately stained. Unbroken. May be abnormal.
Air Cell	1/8 inch or less in depth. Practically regular.	3/16 inch or less in depth. Practically regular.	3/8 inch or less in depth. May be free or bubbly.	May be over 3/8 inch in depth. May be free or bubbly.
White	Clear. Firm.	Clear. May be reasonably firm.	Clear. May be slightly weak.	May be weak and watery. Small blood clots or spots may be present.*
Yolk	Outline slightly defined. Practically free from defects.	Outline may be fairly well defined. Practically free from defects.	Outline may be well defined. May be slightly enlarged and flattened. May show definite but not serious defects.	Outline may be plainly visible. May be enlarged and flattened. May show clearly visible germ development but no blood. May show other serious defects.

*If they be small (aggregating not more than 1/8 inch in diameter)

For eggs with dirty or broken shells, the standards of quality provide three additional qualities. These are:

Dirty	Check	Leaker
Unbroken. May be dirty.	Checked or cracked but not leaking.	Broken so contents are leaking.

Ordinance Regulating the Processing of Eggs and Egg Products

(Tentative 1966 Recommendations of the Public Health Service. This has not yet been officially recommended by the PHS, although this draft appears satisfactory to many Food and Drug Officers. Those parts of the narrative which are in parenthesis are not parts of the Ordinance, but are explanatory detail of the particular section of the ordinance. Such detail has not been included for every section of the ordinance since it would merely be a repetition of explanatory detail already given in other ordinances presented in this book.)

An ordinance defining eggs, adulterated, misbranded, egg processing operations, regulatory authority, utensils, equipment, etc.; providing for the sale of only unadulterated, clean, wholesome, properly labeled eggs and egg products; cleaning and sanitizing procedures for egg equipment and utensils, sanitary facilities and controls, and other facilities; requiring permits for egg processing operations; regulating the inspection of such operations; providing for the examination and condemnation of eggs and providing for the enforcement of this ordinance and the fixing of penalties.

Be it ordained by the _____ of the municipality of _____ as follows:

Section 1. Definitions

The following definitions shall apply in the interpretation and enforcement of this ordinance:

Adulterated shall mean the condition of eggs (a) if they bear or contain any poisonous or deleterious substance in a quantity which may render them injurious to health; (b) if they bear or contain any added, poisonous, or deleterious substances for which no safe tolerance has been established; (c) if they contain in whole or in part any filthy, putrid, decomposed substance or are otherwise unfit for human consumption; (d) if they have been processed, prepared, packaged, or held under insanitary conditions whereby they may have become contaminated with filth, or whereby they may have been rendered injurious to health; (e) if they be in whole or in part of the product of a diseased animal; and (f) if their container be composed in whole or in part of any poisonous or deleterious substance which may render the contents injurious to health.

Approved shall mean acceptable to the regulatory authority based on his determination as to conformance with appropriate standards and good public health practice.

Closed shall mean fitted together snugly leaving no opening large enough to permit the entrance of vermin.

Corrosion-resistant material shall mean a material which maintains its original surface characteristics under prolonged influence of the eggs and egg products, cleaning compounds, and sanitizing solutions which may contact it.

Dried eggs and egg products shall mean liquid whole eggs, whites or yolks, and added permissive substances for improvement of the product, from which moisture has been removed by a commercial drying process.

Easily cleanable shall mean readily accessible and of such material and finish and so fabricated that residue may be completely removed by normal cleaning methods.

Edible eggs shall mean eggs which are fit for human food and which are not defined as inedible herein.

Egg-contact surfaces shall mean those surfaces of equipment, and/or utensils with which eggs or egg products come in contact, and those surfaces with which eggs or egg products may come in contact and drain back on surfaces normally in contact with eggs or egg products.

Egg processing establishment shall mean any place, premises, or establishment where eggs or egg products are broken, separated, mixed, packaged, filled, heat treated, or otherwise processed or prepared for distribution in a liquid, frozen, or dried condition.

Egg products shall mean any liquid eggs, egg whites, egg yolks or combination of these, and permissive substances that may be added to liquid, frozen or dried eggs.

Eggs shall mean eggs from chickens, ducks, turkeys or guineas, which are intended for use or for sale in whole or in part for human consumption.

Frozen eggs and egg products shall mean eggs and egg products which have been reduced to the solid state by refrigeration.

Inedible eggs shall mean eggs which are designated as black rots, white rots, mixed rots, sour eggs, eggs with green or bloody whites, eggs with stuck yolks, moldy eggs, musty eggs, eggs showing large blood or meat spots, blood rings, eggs containing embryo chicks at or beyond the blood ring state, eggs that are adulterated as defined herein, and any egg in such condition that washing or breaking will result in contamination of the contents.

Misbranded shall mean the presence of any written, printed or graphic matter, upon or accompanying egg containers which is false or misleading, or which violates applicable State or local labeling requirements.

Pasteurization shall mean the treatment of every particle of liquid eggs or egg products by a process which is proven effective in the destruction of pathogenic microorganisms and which is approved by the regulatory authority.

Safe temperatures shall mean temperatures of 45° F. or less or 140° F. or more.

Sanitize shall mean effective bactericidal treatment of clean surfaces of equipment and utensils by a process which has been approved by the regulatory authority and is effective in destroying microorganisms, including pathogens.

Sealed shall mean free from cracks or other openings which permit the entry or passage of moisture.

Wholesome shall mean in sound condition, clean, free from adulteration, and otherwise suitable for use as human food.

Section 2. Location, Construction, Facilities, and Maintenance of Egg Processing Establishments.

Location: Grounds and premises shall be well drained, maintained in a clean, neat condition and free from refuse, waste materials, and other objectionable materials and accumulations.

Construction and Maintenance: Floors, walls, and ceilings in the establishment shall be of such construction as to be easily cleaned, shall be smooth, and shall be kept clean and in good repair. Processes and operations shall be so located and/or partitioned so as to separate those operations which may cause contamination of eggs, egg products, or ingredients to be utilized in egg processing.

(All interior walls separating processes and operations shall extend from the floor to the ceiling. Such walls shall be free from openings, except for necessary openings such as for conveyors, or reach-through operations, and doorways. Doorways shall be equipped with doors of the solid type which are kept in good repair.

(Ceilings, or the underside of the roof if used as a ceiling, and exposed overhead structures, in all rooms or areas where eggs, egg products, or ingredients are processed or stored, where utensils are washed, in refuse rooms, and in all other rooms or areas where floors are not kept dry, shall have washable, preferably light-colored surfaces, with all joints sealed. The surfaces of ceilings in cooler and freezer rooms shall be as smooth as steel-trowled cement-plaster finish. If the construction of the underside of the roof and of the structural members in any area of the plant be such that they cannot easily be kept clean,

a ceiling beneath the structural members shall be required.

(Separation and Partitioning of Processes:

(Separate rooms or enclosures shall be provided for: Receiving and shipping; storage and supplies; refrigerated storage of shell eggs; candling, washing, sanitizing, and drying of shell eggs; breaking, separation, pasteurization, and cooling; storage and packaging of the final product when liquid or to be frozen; drying and packing; toilets and dressing rooms or areas; storage of containers of refuse; Provided, That refuse rooms shall not be required in establishments where solid wastes from egg processing operations are removed and disposed of immediately.

(Only approved operations shall be conducted in an egg processing establishment. If products be prepared for other than human consumption, such operations shall be conducted in rooms which are separated from the egg processing establishment by an unbroken wall, or be located in a building entirely apart from the building or buildings where eggs or egg products are processed for human consumption.)

Lighting: All areas in which eggs, egg products or ingredients are processed, examined, or stored, or equipment and utensils are washed, handwashing areas, dressing and locker rooms, and toilet rooms shall be well lighted. Ample natural and/or artificial light shall be provided in all processing and storage rooms.

(At least 50 foot-candles of light shall be provided on work surfaces in areas where eggs and egg products are examined for cleanliness or wholesomeness; at least 30 foot-candles of light on all other working surfaces; and at least 5 foot-candles of light at a distance of 30 inches above the floor in all other areas of the establishment: Provided, That egg candling operations shall be exempted from this requirement.)

Ventilation: All rooms in which eggs or egg products are processed, or equipment and utensils are washed, dressing or locker rooms, toilet rooms, and refuse storage areas shall be well ventilated. Equipment giving off noxious odors, fumes, or vapors shall be ventilated to the outside air. Ventilation systems shall not create conditions whereby eggs or egg products are subjected to contamination.

(Mechanical ventilating equipment shall be so designed, located, and controlled as to minimize conditions whereby eggs, egg products, or ingredients, or processing equipment may be subjected to airborne contamination from nearby or preceding or other operations, or from other sources.)

Dressing Rooms and Lockers: Adequate facilities shall be provided for the orderly storage of employees' clothing and personal belongings. Where employees routinely change clothes within the egg processing establishment, one or more dressing rooms or designated areas shall be provided for this purpose. Such designated areas shall be located outside of the processing areas, egg and egg products storage areas, and the utensil-washing and storage areas: Provided, That, when approved, such an area may be located in a storage room where only completely packaged dry ingredients or other dry materials are stored. Designated areas shall be equipped with adequate lockers, and lockers or other suitable facilities shall be provided in dressing rooms. Dressing rooms and lockers shall be kept clean. Non-absorbent containers or laundry bags shall be provided and damp or soiled linens and clothes shall be kept therein until removed for laundering.

Water Supply: The water supply shall be adequate, of a safe, sanitary quality, and from an approved source. Hot and cold running water, under pressure, shall be provided in all areas where eggs or egg products are processed, or equipment, utensils, or containers are washed.

Sewage Disposal: All sewage shall be disposed of in a public sewerage system, or, in the absence thereof, in an approved manner.

Plumbing: Plumbing shall be so sized, installed, and maintained in order to carry adequate quantities of water to required locations throughout the establishment; to prevent

contamination of the water; to properly convey sewage and liquid wastes from the establishment to the sewerage or sewage-disposal system; and not to constitute a source of contamination of eggs, egg products or ingredients, equipment, or utensils, or create an insanitary condition or nuisance.

Toilet Facilities: Each egg-processing establishment shall be provided with adequate, conveniently located toilet facilities for its employees. Toilet fixtures shall be of sanitary design and readily cleanable. Toilet facilities, including rooms and fixtures, shall be kept in a clean condition and in good repair. The doors of all toilet rooms shall be self-closing. Toilet tissue shall be provided. Easily cleanable receptacles shall be provided for waste materials, and such receptacles in toilet rooms for women shall be covered.

Handwashing Facilities: Each egg-processing establishment shall be provided with adequate, conveniently located handwashing facilities for its employees, including a lavatory or lavatories equipped with hot and cold tempered running water, hand-cleansing soap or detergent, and approved sanitary towels or other approved hand-drying devices. Such facilities shall be kept clean and in good repair.

Egg Wastes and Rubbish Disposal: All egg waste and rubbish containing egg wastes shall, prior to disposal, be kept in leakproof, nonabsorbent containers which shall be kept covered with tight-fitting lids when filled or stored, or not in continuous use: Provided, That such containers need not be covered when stored in a special verminproofed room or enclosure, or in an egg waste refrigerator. All other rubbish shall be stored in containers, rooms, or areas in an approved manner. The rooms, enclosures, areas, and containers used shall be adequate for the storage of all egg waste and rubbish accumulating on the premises. Adequate cleaning facilities shall be provided, and each container, room, or area shall be thoroughly cleaned after the emptying or removal of egg waste and rubbish. All egg waste and rubbish shall be disposed of with sufficient frequency and in such a manner as to prevent a nuisance.

(Egg waste storage rooms or enclosures shall be constructed of easily cleanable, washable materials and shall be vermin proofed. Floors and walls shall be of smooth and relatively non-absorbent materials. Rubbish containers outside the establishment shall be stored either on a concrete or equally impervious slab, or on a rack which is at least 12 inches above the ground for a single bank of containers, or 18 inches above the ground for a multiple bank of containers.)

Vermin Control: Effective measures shall be taken to prevent the entrance of vermin into the establishment and the breeding or presence of vermin on the premises.

Sanitary Design, Construction, and Installation of Equipment and Utensils: All equipment and utensils shall be so designed and of such material and construction as to be smooth, easily cleanable, and durable, and shall be in good repair; and the product-contact surfaces of such equipment and utensils shall be easily accessible for cleaning, be nontoxic, corrosion resistant, and relatively nonabsorbent.

All equipment shall be so installed and maintained as to facilitate the cleaning thereof, and of all adjacent areas.

Single-service articles shall be made from nontoxic materials.

(All egg-contact surfaces, unless designed for in-place cleaning, shall be accessible for manual cleaning and for inspection either: Without being disassembled; or by disassembling without the use of tools; or by easy disassembling with the use of simple tools kept available near the equipment.

(Equipment intended for in-place cleaning shall be so designed and constructed that:
(Cleaning and sanitizing solutions can be circulated throughout a fixed system.
(Cleaning and sanitizing solutions will contact all interior surfaces.
(The system is self-draining or otherwise completely evacuated.
(Cleaning procedures result in thorough cleaning of the equipment.

(Equipment Installation:

(Equipment which is placed on tables or counters, unless readily movable, shall be sealed thereto or mounted on legs or feet at least 4 inches high, and shall be so installed as to facilitate the cleaning of the equipment and areas adjacent thereto.

(Floor-mounted equipment, unless readily movable, shall be sealed to the floor; or shall be installed on raised platforms of concrete or other smooth masonry in such a manner as to prevent liquids or debris from seeping or settling underneath, between or behind such equipment in spaces which are not fully open for cleaning and inspection; or such equipment shall be elevated at least 6 inches above the floor. The space between adjoining units, and between a unit and the adjacent wall, shall be closed unless exposed to seepage, in which event it shall be sealed; or sufficient space shall be provided to facilitate easy cleaning between, behind, and beside all such equipment.)

Cleanliness of Equipment and Utensils: All utensils and egg-contact surfaces of equipment shall be thoroughly cleaned and sanitized after each usage. Non-egg contact surfaces of equipment shall be cleaned at such intervals as to keep them clean and in a sanitary condition. After cleaning and until use, all utensils and egg-contact surfaces of equipment shall be stored and handled as to be protected from contamination. All single-service articles shall be stored, handled, and disposed in a sanitary manner, and shall be used only once.

Sources of Supply: All eggs, egg products, and ingredients in egg processing establishments shall be from approved sources, and shall be clean, wholesome, free from spoilage, adulteration, and misbranding.

Protection of Eggs, Egg Products, and Ingredients: All eggs, egg products, and ingredients while being processed, stored, packaged or handled in egg processing establishments, or while being transported between such establishments, shall be protected from contamination, spoilage, and other conditions whereby they may become unsafe or otherwise unfit for human consumption. Only such poisonous and toxic materials as are required to maintain sanitary conditions and for sanitization purposes may be used or stored in egg processing establishments. Poisonous and toxic materials shall be identified, and shall be used only in such a manner and under such conditions as will not contaminate eggs, egg products, or ingredients, or constitute a hazard to employees or customers.

(Protective Equipment and Facilities:

(Conveniently located approved refrigeration, freezing, and heating equipment and/or facilities shall be provided as needed to assure the maintenance of all eggs, egg products, and ingredients at safe temperatures during processing, storage, and distribution. Each such item of equipment and/or facility shall be equipped with an approved temperature indicating and/or recording device which is properly located, installed, and utilized.

(Where necessary to prevent contamination of eggs and egg products, covers shall be provided for tanks and containers.

(Processing:

(Only clean, wholesome eggs shall be used in the production of pasteurized eggs and egg products.

(Eggs shall be candled, washed, and processed in a manner to assure that:

(All shell eggs shall be free of cracks and punctures, and liquid eggs shall be free of all extraneous materials, and eggs and egg products that are mishandled shall be rejected.

(As the last step in the washing operation, shell eggs shall be subjected to a flow or spray of sanitizing solution sufficient in quantity and pressure, and distributed in such a manner as to sanitize the exterior egg shell. Immersion of shell eggs in a tank or other container of water for such purpose shall be prohibited.

(Prior to the shell egg reaching the egg cracking machine, means shall be provided for air drying the shell of the egg so as to prevent the sanitizing solution from gaining entrance to the liquid egg.

(The placing of eggs or egg products upon the floor shall be prohibited; Provided, That eggs which are so soiled or which are of such nature as to preclude adequate cleaning shall be disposed of as inedible eggs.

(Temperatures:

(Shell eggs shall be stored at 45° F. or below, and at no time prior to breaking shall the temperature of such eggs exceed 55° F.

(Liquid eggs and egg products shall, following breaking, be kept at a temperature of 45° F. or below, except when being stabilized, pasteurized, or dried; Provided, That liquid eggs and egg products which are pasteurized within 30 minutes after breaking shall be exempt from this requirement.

(Pasteurization:*

(All liquid eggs and egg products shall be pasteurized by one of the following methods:

(Every particle of liquid whole eggs, yolks, or combination of these, and when other edible ingredients are added shall be heated to a temperature of 142° F. and held continuously at such temperature for not less than 3 1/2 minutes, in approved and properly operated equipment; or

(Every particle of liquid egg white, after stabilization by pH adjustment and addition of suitable metallic salts, shall be heated to a temperature of at least 142° F. and held continuously at such temperature for not less than 3 1/2 minutes, in approved and properly operated equipment; or

(Any other process which has been demonstrated to be equally effective, as those processes set forth herein and has been approved by the regulatory authority.

(Immediately following pasteurization, the liquid egg product shall be cooled to 45° F. or below and maintained at such temperature, except where the product goes directly to the drying operation.

(Frozen Eggs and Egg Products:

(Frozen eggs and egg products shall be kept at such temperatures as to remain frozen, except when being thawed for processing.

(When eggs or egg products are defrosted by being permitted to thaw in refrigerated coolers, the temperature of the product in the facility in which such defrosting takes place shall not exceed 45° F.

(Where containers of frozen egg products are submerged in water for defrosting, the temperature of the water in thawing tank or vat shall not exceed 70° F. A continuous flow of potable water through the thawing tank or vat shall be provided, and the rate of flow shall be sufficient to keep the water in the tank or vat clear. If defrosting be accomplished by placing containers of the product in perforated or mesh-type containers under sprays of potable water, the temperature of the water shall not exceed 70° F.; the water shall be sprayed upon the product continuously and drain readily from the container; and the bottom of the container shall be raised above the floor on legs or other supports. Adequate protection shall be provided to prevent adulteration where thawing of frozen egg products is accomplished using water.

(Ice:

(Ice shall be made from water meeting the requirements for potable water in an icemaking machine which is located, installed, operated, and maintained so as to prevent contamination of the ice, or shall be obtained from an approved source.

(Ice shall be handled, transported, and stored in such a manner as to be protected against contamination. If block ice be used, the outer surfaces shall be thoroughly rinsed before it is

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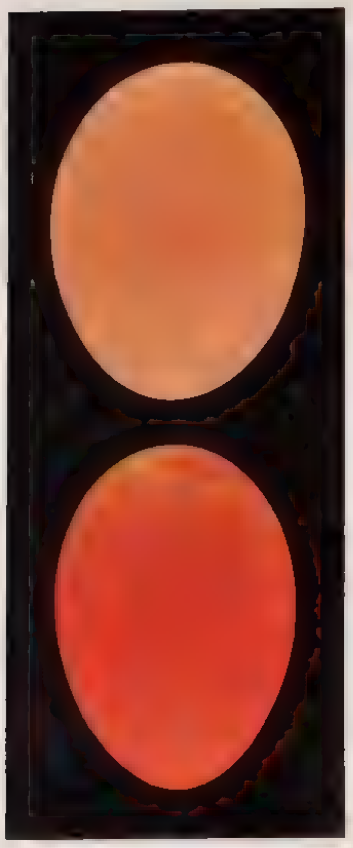
*Time and temperatures described here are at present only tentative and may be changed as indicated by results of research concerning the pasteurization of eggs and egg products.

UNITED STATES STANDARDS FOR QUALITY OF INDIVIDUAL SHELL EGGS

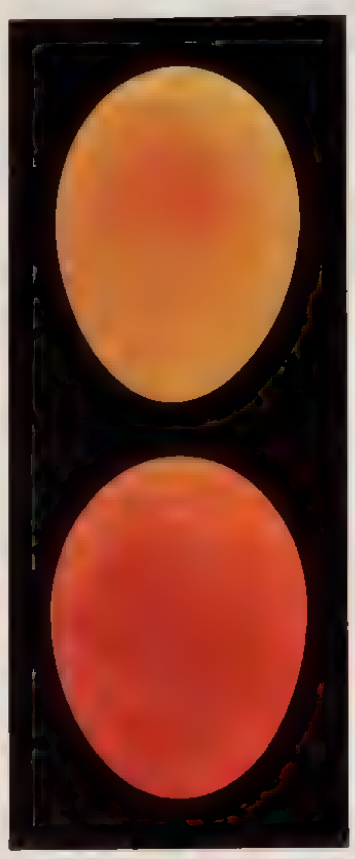
Illustrations of Candled Appearance of White and Brown Eggs Showing Maximum Depth of Air Cell and Outline of Yolk in Each Quality

AA Quality



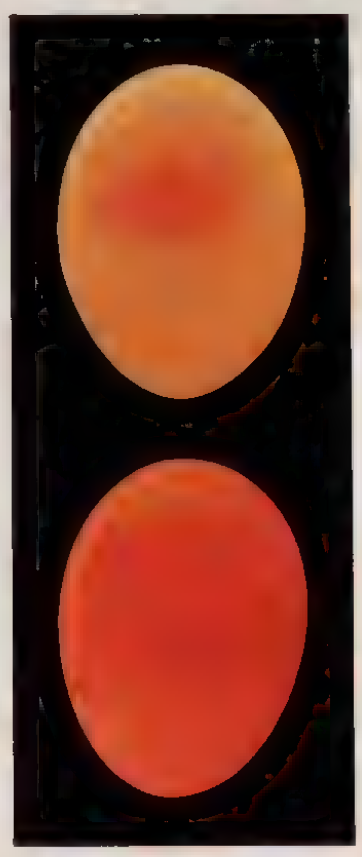
1 Shell—clean unbroken practically normal
2 Air cell—⅛ inch or less in depth, practically regular
3 White—clear, firm
4 Yolk—outline slightly defined, practically free from defects

A Quality



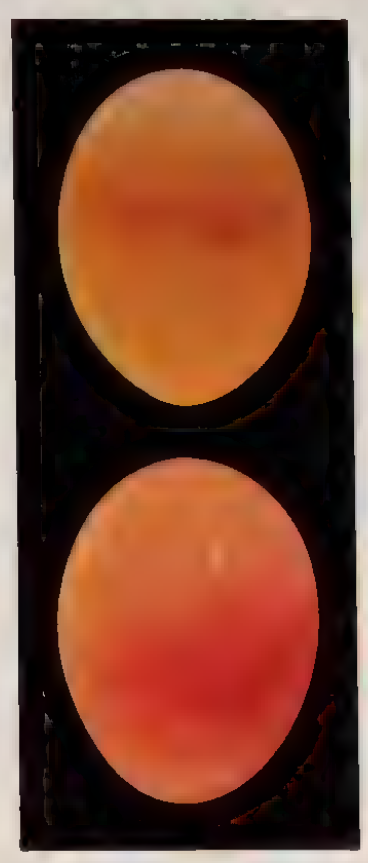
1 Shell—clean, unbroken, practically normal.
2. Air cell—3/16 inch or less in depth; practically regular
3 White—clear; may be reasonably firm.
4. Yolk—outline fairly well defined, practically free from defects

B Quality



1 Shell—clean, to slightly stained; unbroken, may be slightly abnormal
2. Air cell—⅜ inch or less in depth; may be free or bubbly.
3 White—clear, may be slightly weak.
4 Yolk—outline well defined, may be slightly enlarged and flattened, may show definite but not serious defects.

C Quality



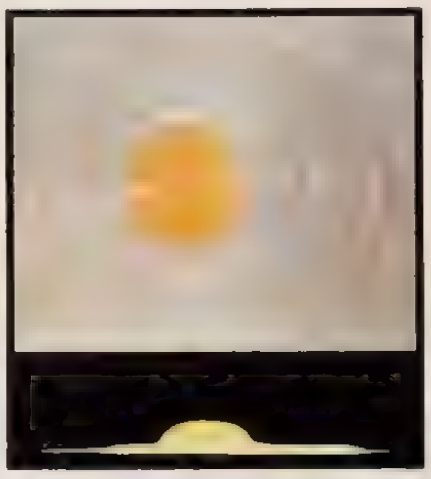
1 Shell—clean, to moderately stained, unbroken, may be abnormal
2 Air cell—may be over ⅜ inch in depth, may be free or bubbly
3. White—may be weak and watery, small blood clots or spots may be present
4 Yolk—enlarged and flattened, may show clearly visible germ development but no blood; may show other serious defects, outline plainly visible

Illustrations of Broken-Out Appearance (Top and Side Views) of Each Quality—⅓ Actual Size

AA or Fresh Fancy Quality

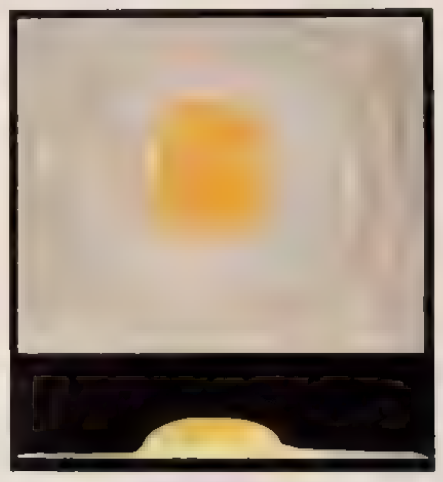
1 Egg covers small area, much thick white surrounds yolk, has small amount of thin white, yolk round and upstanding
2 Albumen firm—72 Haugh units minimum

A Quality



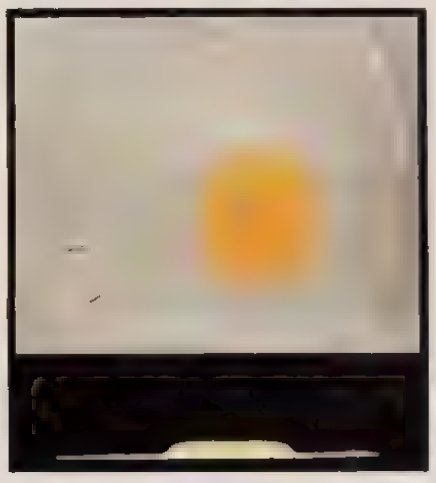
1 Egg covers moderate area, has considerable thick white, medium amount of thin white, yolk round and upstanding.
2 Albumen reasonably firm—60 Haugh units minimum.

B Quality



1 Egg covers wide area; has small amount of thick white, much thin white, yolk somewhat flattened and enlarged
2 Albumen may be slightly weak—31 Haugh units minimum

C Quality



1. Egg covers very wide area, has no thick white; large amount of thin white thinly spread; yolk very flat and enlarged
2 Albumen may be weak and watery—less than 31 Haugh units

(Graders should check their work by breaking out an egg occasionally and comparing it with this chart.)

Illustrations of Types of Shell Condition and Shell Cleanliness

AA, Fresh Fancy & A Quality (Practically Normal)

Good even texture and strength, free from rough areas or thin spots Slight ridges and rough areas permitted

B Quality (Slightly Abnormal)

May be unusual in shape, slightly faulty in texture or strength, definite ridges, no pronounced thin or rough areas

C Quality (Abnormal)

May be decidedly misshapen or faulty in texture or strength May show pronounced thin, rough or ridged areas

AA, Fresh Fancy, A Quality (Clean)

The shell must be clean and free of stains or discolorations that are readily visible

B Quality (Slight Stains)

Localized stain approximately 1/32 of the shell surface.

Scattered stain approximately 1/16 of the shell surface

C Quality

Slight stains covering more than 1/16 of the shell surface

Moderate stains covering less than 1/4 of the shell surface

Dirty

Moderate stains covering more than 1/4 of the shell surface

Prominent stains

Adhering dirt.

Check

Shell broken but membrane intact (candled appearance)

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used for any purpose. Where ice crushers are used they shall be maintained in a clean condition and shall be covered when not in use.

(Block ice shall be placed on clean pallets or platforms, and washed by spraying the outer surfaces with potable water immediately before such ice is crushed.)

Health and Disease Controls: No person while affected with any disease in a communicable form, or while a carrier of such disease, or while afflicted with infected wounds, sores, or a respiratory infection shall work in any area of egg processing establishments in any capacity in which there is a likelihood of such person contaminating eggs, egg products, or ingredients, or egg-contact surfaces with pathogenic organisms, or transmitting disease to other individuals; and no person known or suspected of being affected with any such disease or condition shall be employed in such an area or capacity. If the manager or person in charge of the establishment has reason to suspect that any employee has contracted any disease in a communicable form or has become a carrier of such disease, he shall notify the regulatory authority immediately.

Cleanliness: All employees shall wear clean outer garments, maintain a high degree of personal cleanliness, and conform to hygienic practices while on duty. They shall wash their hands thoroughly in an approved hand-washing facility before starting work, and as often as may be necessary to remove soil and contamination. (Supervision of hand-washing is a specific responsibility of management.) No employee shall resume work after visiting the toilet room without first washing his hands.

Permits: It shall be unlawful for any person to operate an egg processing establishment within the municipality of _____, or its police jurisdiction, who does not possess a valid permit issued to him by the regulatory authority. Only a person who complies with the requirements of this ordinance shall be entitled to receive and retain such a permit. Permits shall not be transferable from one person to another person or place. A valid permit shall be posted in every egg processing establishment.

Inspection of Egg-Processing Establishments: At least once every six months, the regulatory authority shall inspect each egg-processing establishment located in the municipality of _____, or its police jurisdiction, and shall make as many additional inspections and reinspections as are necessary for the enforcement of this ordinance.

Examination and Condemnation of Eggs and Egg Products: Eggs and egg products may be examined or sampled by the regulatory authority as often as may be necessary to determine freedom from adulteration or misbranding. The regulatory authority may, upon written notice to the owner or person in charge, place a hold order on any eggs, egg products, or ingredients which he determines or has probable cause to believe to be unwholesome or otherwise adulterated, or misbranded. Under a hold order, such products shall be permitted to be suitably stored. It shall be unlawful for any person to remove or alter a hold order, notice, or tag placed on eggs, egg products, or ingredients by the regulatory authority, and neither such food nor the containers thereof shall be relabeled, repacked, reprocessed, altered, disposed of, or destroyed without permission of the regulatory authority, except on order by a court of competent jurisdiction. After the owner or person in charge has had a hearing, and on the basis of evidence produced at such hearing, or on the basis of his examination in the event a written request for a hearing is not received within 10 days, the regulatory authority may vacate the hold order, or may, by written order, direct the owner or person in charge of the eggs, egg products, or ingredients which was placed under the hold order to denature or destroy such food or to bring it into compliance with the provisions of this ordinance: Provided, That such order of the regulatory authority to denature or destroy such food or bring it into compliance with the provisions of this ordinance shall be stayed if the order be appealed to a court of competent jurisdiction within 3 days.

Egg-Processing Establishments Outside Jurisdiction of the Regulatory Authority: Egg products from egg-processing establishments outside the jurisdiction of the regulatory authority of the municipality of _____ may be sold within the municipality of _____ if such egg-processing establishments conform to the

provisions of this ordinance or to substantially equivalent provisions. To determine the extent of compliance with such provisions, the regulatory authority may accept reports from responsible authorities in other jursidictions where such egg-processing establishments are located.

Review of Future Construction: When an egg-processing establishment is hereafter constructed or extensively remodeled, or when an existing structure is converted for use as an egg-processing establishment, properly prepared plans and specifications for such construction, remodeling, or alteration, showing layout, arrangement and construction materials of work areas, and the location, size and type of fixed equipment and facilities, shall be submitted to the regulatory authority for approval before such work is begun.

Procedure When Infection is Suspected: When the regulatory authority has reasonable cause to suspect possibility of disease transmission from any egg-processing establishment employee, the regulatory authority shall secure a morbidity history of the suspected employee, or make such other investigations as may be indicated, and take appropriate action. The regulatory authority may require any or all of the following measures:

The immediate exclusion of the employee from all egg processing establishments;

The immediate closure of the egg processing establishment concerned until, in the opinion of the regulatory authority, no further danger of disease outbreak exists;

Restriction of the employee's services to some area of the establishment where there would be no danger of transmitting disease; and

Adequate medical and laboratory examinations of the employee, of other employees, and of his and their body discharges.

Penalties: Any person who shall violate any of the provisions of this ordinance shall be guilty of a misdemeanor and, upon conviction thereof, shall be punished by a fine of not more than $_____. In addition thereto, such persons may be enjoined from continuing such violations. Each day upon which a violation occurs shall constitute a separate violation.

Repeal and Date of Effect: This ordinance shall be in full force and effect 12 months after its adoption and publication as provided by law, and at that time, all ordinances and parts of ordinances in conflict with this ordinance are hereby repealed.

Unconstitutionality Clause: Should any section, paragraph, sentence, clause, or phrase of this ordinance be declared unconstitutional or invalid for any reason, the remainder of said ordinance shall not be affected thereby.

Chemical Tests.

Detection of Washed Eggs. This test is based on the fact that clean, unwashed eggs contain both potassium and chlorine (chlorides) on the exterior of the shell. A drop of distilled water is placed on the shell of an egg. Later the drop is transferred to a microscopic slide. A drop of 0.1 N silver nitrate is added to the slide. If a flocculent precipitate forms by microscopic observation, it indicates the presence of chloride. Another drop is then added --this time, cobalt nitrate. The formation of crystals within 20 minutes, observed microscopically, indicates the presence of potassium.

Eggs washed with soap solutions can be recognized by their feel, by a trained inspector.

Dectection of Scraped Eggs. Scraped or abrased eggs may be detected by immersing them in any of such dyes as, methylene blue, brilliant green, malachite green, safranine, or an aqueous solution of rosaniline hydrochloride. These dyes stain the protein material normally covering the shell of eggs. Unstained spots indicate that this film has been removed. Sandblasted eggs may be detected either by this test or the one for "detection of washed eggs."

Detection of Oil-treated Eggs. Oiled eggs are detected simply by dipping the end of the egg in ethyl ether for a second. An oily ring is seen at the edge of the ether-dipped part.

Total Solids. Liquid whole eggs have about 26 to 27% total solids. Any adulteration by addition of liquid will decrease the percentage of total solids. The total solids in dried eggs will depend upon the amount of moisture present.

Acidity. As eggs decompose their acidity increases. A better test for spoilage is that for acid-soluble phosphoric acid.

Acid-soluble Phosphoric Acid. Strictly fresh eggs contain between 80 and 95 milligrams of acid-soluble phosphoric acid per 100 grams, cold storage (11 months) eggs contain between 118 and 141 milligrams, and black rots contain 470 to 722 milligrams. For liquid and dried eggs, corresponding degrees of decomposition may be measured by increases in acid-soluble phosphoric acid.

Ammoniacal Nitrogen. Deterioration of liquid eggs shows a progressive increase in ammonia nitrogen. At the beginning of a storage period, fresh eggs contain .0011 to .0015% of ammoniacal nitrogen on a wet basis. At 7 1/2 months, this increases to .0023 to .0028%. Black rots are found to have .0229 to .0800% ammoniacal ammonia.

There are other chemical tests that may be performed on liquid and dried eggs, but the above are at present considered the most important for determining quality. All these tests are described in detail in "Official and Tentative Methods of Analysis of the Association of Official Agricultural Chemists." The latter book is a monumental exposition of chemical tests.

Bacteriological Tests.

Shell Eggs. The bacterial contamination of shell eggs can be simply detected by streaking a loop of material from the yolk onto an agar plate. When this is incubated, it shows the bacteria to be present either in large numbers or not at all.

Frozen Egg Yolks. The sample is thawed by warming it at 37° C. on a water bath, diluting and plating it on standard nutrient agar, as for milk, and incubating at 20° C. for five days. Esch. coli is determined by dilution in lactose broth tubes, and partially identifying it on E. M. B. plates.

Powdered Egg. A 1-gram sample is transferred to a 99-milliliter water blank, and plated on standard nutrient agar in Petri dishes as described for milk.

Collection and Preparation of Samples of Liquid, Frozen, and Dried Eggs.

No sample rules can be made for the collection of a sample representative of the average of any particular lot of egg material, as conditions may differ widely. Experienced judgment must be used in each instance. If large lots be under examination, it is best to draw a number of samples for separate analyses rather than attempt to get one composite representative sample.

Liquid Eggs. Secure representative container or containers. Mix contents of container thoroughly and draw about 300 grams. A long-handled dipper or ladle serves well. Keep sample in hermetically sealed jar in cool place. Report odor and appearance.

Frozen Eggs. Secure representative container or containers. Examine contents as to odor and appearance. The condition of the contents can be determined best by boring a hole to the center of a container with auger and noting odor as the auger is withdrawn. If impossible to secure individual containers, samples may consist of the composite of the borings from the contents of each container. Take borings midway between the center and circumference of the top of can from at least 3 widely separated parts and extend them as near to the bottom of can as possible. Collect about 300 grams of the sample. Keep sample in hermetically sealed jar in cool place and in frozen state if possible. Before analyzing, warm sample in bath held below 50° C. and mix well.

Dried Eggs. Secure representative container or containers. For small packages, take entire parcel or parcels for the sample. For boxes and barrels, remove top layer to depth of around 6 inches with a flour scoop or other convenient instrument. Draw small quantities of sample totalling 300 to 500 grams from accessible part of container and place in a hermetically sealed jar. Report odor and appearance. Prepare sample for analysis by mixing 3 times through domestic flour sifter to assure complete breaking up of lumps. Keep in hermetically sealed jar in cool place.

Flaked and Drum-dried Eggs. Collect sample as directed for powdered eggs. Report odor and appearance. Prepare albumin samples for analysis by grinding in mill to pass entirely through a 60-mesh sieve, and whole egg and yolk samples to pass entirely through a 20-mesh sieve or as fine as is practicable. Keep in hermetically sealed jar in cool place.

Chapter XXII

Seafood Control

The prevention of spoilage, infection, and contamination of Seafood is a complicated technique and requires all the knowledge of the general sanitarian in relation to water supplies, excreta control, personal hygiene and general sanitary housekeeping, and also the special knowledge of the techniques used in harvesting or catching seafoods, their transportation, processing and distribution. Every phase of seafood control is the sanitarian's job. He may work as a sanitarian specialist, devoting all his time to seafood control, or this activity may be just a routine part of his work as is the case in counties along the seaboard or gulf where the seafood industry is an important part of the local economy.

The sanitarian's responsibility is to: a) know the nature of the water and methods by which shellfish are harvested, b) inspect and supervise the operation of establishments in which they are prepared for market, c) evaluate the eligibility of shippers to be certified, d) inspect and supervise the methods and facilities of transporting seafood, e) inspect and supervise the sanitary handling in retail establishments. The sanitarian must, therefore, not only know, in great detail, the sanitary control regulations and the technical procedures, but must also know the signs of freshness or staleness of seafood.

Seafoods are among the most quickly perishable of foods. They are subject to rapid decomposition and spoilage and serve as excellent media for the growth and transmission of pathogenic microorganisms.

Edible fishes include a wide variety of species. They are offered for sale as fresh chilled, frozen, canned, or cured. The shellfish which are usually offered for purchase in the U. S. are oysters, clams, and mussels. The common edible crustaceans include crabs, crayfish, lobsters, and shrimp.

Definitions

Seafoods are marine and fresh-water animal food products. The following types of seafoods may be defined:

Fish is any edible, commercially distributed fresh or salt water member of the animal kingdom classed as fish (Pisces).

Shellfish is any edible, commercially distributed member of the animal kingdom classed under mollusks (Mollusca), usually including oysters, clams and mussels.

Crustacean is any edible, commercially distributed shrimp, crab, lobster or other member of the animal kindgom included under the classification of crustaceans (Crustacea).

Market shellfish are those shellfish which are harvested and/or prepared for sale to the consumer.

Seed shellfish are those shellfish which are harvested for use by the gatherer or for sale to a shellfish planter or grower to be laid down again in growing areas for further growth and cultivation.

Shucked shellfish are those shellfish which have been removed from their shell.

Shell stock are shellfish which remain in their shells.

Fish

The flesh of fish may transmit typhoid fever and salmonella infections on rare occasions. The flesh may also harbor Clostridium botulinum-like bacteria which produce virulent toxins. The

tissues of various fresh water fish, more especially the pike and perch in the great lakes region, may contain encysted larvae of the fish tapeworm, Diphyllobothrium latum, which when ingested in the raw or partially raw state may develop into adult tapeworms in the human intestines. Intestinal and liver fluke diseases may develop from eating uncooked fish in the Far East. Cooking destroys all pathogens which fish may harbor. Boiling destroys the above mentioned toxin. The same curing processes which destroy worm parasites in meat will also destroy them in fish.

Some fish are inherently poisonous at all times, while others develop physiological poisons only at certain times or places. Most of the fishes which are constantly poisonous belong to the family commonly known as globe fish or puffers (Tetrodontidae). Other fish, such as parrot fish, jacks, trigger fish, or king fish are reputed to be poisonous during certain seasons and at certain places in the tropics. The toxic substances are usually associated with the reproductive organs, the ovaries and eggs, but the poisons may also be found in the head or liver. The roe of certain species of sturgeons is poisonous during the spawning season. These toxic substances are not destroyed by boiling. The symptoms of such poisons are more or less similar to other types of food poisoning. Death may ensue in a few hours, or recovery may follow after varying periods of illness.

Fish are covered with a thin layer of mucous substance which increases when the fish dies. The numerous types of bacteria which are found in the sea water grow readily in this film or in the excreta of fish. It is this slime which is largely responsible for the bacterial contamination of fish packing house equipment. Therefore chlorinated sea water should be lavishly used at packing plants to keep the equipment, utensils, floors and other contact surfaces as free of bacteria as possible. Although there is some disagreement as to whether the flesh of living or recently killed fish is always sterile, there is general agreement that infection occurs soon after death. The greater the number of bacteria in each gram of fish tissue, the greater the rate of deterioration and spoilage. Previously frozen fish which has thawed and has been recooled will deteriorate more quickly than fresh fish equally iced. The Escherichia and Aerobacter groups of bacteria may be found in marine fish but seldom when the fish are taken offshore. The use of chlorinated ice (0.6 to 0.2% available chlorine) has been shown to increase the keeping quality of fish packed therein.

There are no bacterial standards for measuring quality of fish. Dependence for determining decomposition must rest on a combination of bacteriological, chemical, and especially organoleptic (appearance, odor, firmness and other sense perceptive qualities) examination.

The freezing of fish should be done quickly at temperatures below 23° F. in order not to cause rupture of the delicate cell walls of the muscle cells, thus preventing the water in the cells from settling out and freezing separately from the jelly-like content.

Salting of fish is usually done by rubbing the washed and dressed fish with 10 to 35% by weight of dry salt and then packing in watertight containers. The salt inactivates the enzyme action and bacterial growth, and causes the water to drain out of the fish flesh by osmotic action. This, however, does not prevent the development of rancidity of the fish oils. Rancidity is observed by odors or by darkening or rusting of the fish. Storage of salted fish in cool warehouses does retard rancidification.

Smoking of fish is usually preceded by salting. The products of combustion of wood further dry out the flesh and preserve it by the penetration of smoke constituents.

Canning of fish is accompanied by sterilization at temperatures of 230 to 240° F. for various periods, depending on the contents and size of the can.

Inspection of Fish: Fresh and sound fish show:

1. Bright red gills, usually closed, and have no abnormal odor.
2. Bright and full eyes with jet-black pupils and transparent cornea.
3. Scales that are adherent.
4. Skin that is free from malodorous slime and not discolored.
5. Flesh that is firm to the touch. The firmness persists longest near the tail.

6. Stiff body and rigid tail.
7. A carcass that will sink in water.
8. Clean abdomen that is free from offensive odor.
9. Blood of normal consistency and fresh red.
10. Flesh adherent to the bone when fish is split.
11. Back bone of a pearly gray color.

Fish which is decomposed show:

1. Pale, gray or yellowish brown, dark red or otherwise abnormally colored gills, which are open or easily opened and may have offensive odor and be slimy.
2. Opalescence of cornea and lack of luster of pupils in 24 hours; sunken, opaque gray eyes and decomposed cornea in 3-4 days.
3. Loose, dull, and easily removable scales.
4. Skin with malodorous slime. Sometimes washing away malodorous slime may reveal, wholesome fish.
5. Soft, friable, limp flesh.
6. Pliable carcass which will float in water.
7. Discolored, malodorous, soft, pulpy abdominal wall, and alkaline to litmus paper.
8. Flesh easily removable from back bone when fish is split.
9. Dark, thin, offensive blood.
10. Pink, discolored around the back bone. The more intense the discoloration the longer the fish has been dead.

Any indication of the latter evidence, or indication of infestation with parasites, or contamination with fungi is cause for rejection. The presence of worms may be evidenced by numerous small holes or small opaque bodies. When it is pertinent, examination should be made for encysted tape worm larvae.

Canned or cured fish products are inspected in the same manner as canned or cured meat products.

Shellfish: Shellfish may carry any of the water-borne diseases, such as typhoid fever, cholera, dysentery and gastroenteritis. Shellfish are inspected for evidence of spoilage, staleness, or adulteration. When oysters, clams, and mussels are fresh they exhibit the following characteristics:

1. The shells are firmly closed or should close immediately when touched.
2. If tapped together, they should sound like hard pebbles.
3. They should sink when placed in water.
4. The shucked oyster should not be discolored, bloated, or give off an offensive or abnormal odor.
5. The exterior of shell is free from excessive dirt or slime.

Oysters

Of all shellfish, oysters are the most frequently consumed, and because of the conditions under which they grow and are handled, they are the most frequently infected with pathogenic germs. When oysters become infected with typhoid bacilli, the organisms do not multiply, but gradually die off. The warmer the temperature at which the oysters are kept, the quicker the germs die. At 45° F., the microorganisms may survive 3 weeks or longer; at 98° F., they may survive one to several days. As in the bacterial examination of water, the presence of the coliform group of bacteria is used as the criterion of contamination. Such examination is expressed in terms of the Most Probable Number (MPN) of bacteria present in 100 ml. of sample. See Table 75. A sample consists of 10 or more oysters (clams or mussels) of not less than 1/2 pint of shucked shellfish. The shellfish liquor and the mascerated flesh are used in the bacterial examination.

Oysters thrive best in water whose salinity is less than that of sea water, therefore they are found growing best in water diluted by fresh streams. But fresh waters are usually contaminated with sewage. Since the food of oysters is microorganic life, they may become infected with

organisms pathogenic to man. And since a good deal of oysters are eaten raw, precautions are of utmost necessity in the growing and handling of this food. Oysters may be contaminated or infected from sewage in their bed waters, from pathogenic organisms in wash and storage waters, from handling during preparation and distribution.

Oysters grown in contaminated waters may be purified by storage in clean, sewage-free, sea water. Under average conditions contaminated oysters will be purified after a period of 24 to 48 hours by such storage, but to be sure of a margin of safety some health authorities require periods of storage in clean water as long as a week. The storage water should be of the same salinity as the water in which they grew. When the salinity is less the oysters become bloated or fatter. Such oysters are known as "floated" oysters. Sale of such oysters is prohibited by federal law on grounds of adulteration.

Oysters feed by passing about 10 gallons of water through their gills daily and filtering out the microorganisms and other particles. The greater the feeding activity of oysters the quicker they will wash themselves clean during storage, but their feeding activity is impaired in temperatures of water lower than 50° F. Consequently storage water should have a temperature higher than 50° F. if adequate cleaning be obtained. Below 45° F. oysters close and cease to feed. This is known as the state of hibernation. In the latter state oysters may purify themselves in 1 to several days. Oysters will not feed in water containing appreciable amounts of chlorine. Chlorinated sea water should not be depended upon for decontaminating oysters. It might be an aid in sterilizing the exterior.

Oysters grown in water grossly contaminated with sewage should not be allowed for sale for human consumption.

When oysters are adulterated with water they become white, spongy of texture, devoid of saline taste, and yield a thin watery liquor on draining.

In fresh oysters, the acidity is equivalent to 1 - 2 milliliters of N/10 alkali per 100 milliliters of liquor. If the pH be between 6.1 and 5.6, it indicates that the oysters are passing from a fresh to a stale state; if between 5.3 and 4.9, it indicates a passing from stale to sour state; if below 5.0, it indicates advanced decomposition.

Oysters in shells and under cool conditions can be kept alive for long periods. When the oyster dies, the shell opens and the meat deteriorates. After shucking, the oyster dies and is subject to deterioration. At first the decomposition results from enzyme action and the action of water and soil bacteria of the following groups: Proteus, Clostridium, Bacillus, Aerobacter, and Escherichia. Later on, spoilage is increasingly caused by: Streptococci, Lactobacilli, and yeasts. Spoilage is retarded by reducing the number of microorganisms by thoroughly washing the oysters, and especially by maintaining temperature below 45° F. Ice must not come into contact with the oysters since the water will adulterate the liquor.

A copper green discoloration of the body of the oyster may be due to copper derived from the waters in which the oyster was grown. A dark green discoloration may be due to ingestion of quantities of the microorganism, Navicula fusiformis, a diatom. Shucked oysters may develop a pink color while in storage or in transit. This is due to a chromogenic yeast-like fungus contaminating the lot. This organism will grow at low temperatures, is resistant to drying, and is difficult to remove by washing the oysters. It is killed by a 1:2500 dilution of formaldehyde, and therefore this organism can be controlled by disinfecting all utensils, benches, bins, and wood work with this solution at suitable intervals. While there is no evidence that oysters with these green or pink discolorations are injurious to health they should nevertheless be rejected because such evidence indicates lack of freshness and the necessity to examine for decomposition.

All discolored oysters should be rejected also if they appear gassy or milky. They should also be rejected if a dark or black ring appears on the inner side of the shell.

Ordinary cooking cannot be relied upon to kill pathogens in oysters. Effective heating practices are:

1. Placing oysters in cold milk and heat to boiling point.
2. Placing oyster in boiling milk and continue boiling for 5 minutes.
3. Frying about 10 minutes.
4. Cooking escalloped oysters at oven temperature for 15-20 minutes.
5. Exposure to live steam for 5-10 minutes.

Certification of Oyster Shippers: The present method of preventing the sale of contaminated oysters is based on the cooperation of the state sanitary officials and the United States Public Health Service. The State has jurisdiction over the oyster industry in its own domain, and is invested with the power to supervise the harvesting, handling, shipping and marketing of oysters in accordance with its own laws and regulations. It determines the waters from which safe oysters may be taken, issues licenses to individuals permitting them to take oysters, and inspects and supervises the operation of establishments in which oysters are prepared for market. The states issue certificates to firms or individuals who comply with the sanitary measures, and copies of these certificates are submitted to the U.S.P.H.S. If the latter also approves this certification, the name of the person or firm is placed on a list of shippers approved by the U.S. P.H.S. This list is sent at regular intervals to the various state health departments for their information in control of oysters coming in from other states.

Preparation of Shucked Oysters: The process of preparing shucked oysters from shell oysters varies somewhat in different localities but is essentially as follows:

The shell containing the oyster, which may have been washed to remove adhering dirt, silt, etc., is opened, the muscle of the oyster cut from the shell, and the oyster removed and placed into a shucking pail. In some plants the shucking pails contain no fresh water, in some the shucking pails are partly filled with fresh water, and in others the pails are perforated. In some plants, immediately after shucking, the oysters are dropped by the shucker into a trough containing flowing water by which the oysters are carried to the place in the plant where they are washed. This is called "fluming." The oysters, if not already drained during the shucking process, are drained to remove the liquid which has exuded from them and any which was in the shucking pail. The oysters are then washed to remove any foreign adhering matter such as sand, dirt, silt, pieces of shell, etc. After washing, the oysters are drained to remove wash water, and packed without the addition of any other substance.

There is considerable variation in the methods of washing. In some plants the oysters, either individually or in mass, are washed on a strainer, usually called a "skimmer," with a stream or spray of water. In some plants the oysters are placed into a container with water and agitated. A very common method of washing, particularly on the Atlantic and Pacific Coasts, is known as "blowing." In this process the oysters are placed in a tank with water and agitated by a current of compressed air usually introduced through a pipe at the bottom of the tank. Blowing is an efficient method of cleaning the oysters and 3 to 5 minutes blowing time is generally sufficient. In order to remove a black pigment which is sometimes found on the mantle of Pacific oysters it is at times necessary to blow such oysters for longer periods. This pigment is not harmful but it detracts from the appearance of the oysters.

When oysters of any species are removed from the shell and placed in contact with fresh water some of their soluble constituents are removed and the oysters absorb some of the water. Generally the amount of water absorbed and the amounts of soluble constituents lost are in direct relation to the length of time the oysters are in contact with fresh water. Contact of shucked oysters with fresh water generally results in increasing their size due to water absorption, in loss of flavor and of desirable nutritive ingredients. This is contrary to the interest of consumers. Prolonged contact of oysters with fresh water during the washing process is one of the chief causes of such abuses. Oysters should not be washed longer than is necessary to clean them. It is impracticable to prescribe a uniform method of washing which is effective and unobjectionable or to specify the exact time necessary for washing oysters that will be applicable to all oysters at all times. A reasonable method of preventing excessive or unnecessary absorption of water is to limit the total length of time during which oysters are in contact with fresh water.

When oysters are agitated during contact with fresh water, whether the agitation be by blowing or otherwise, the action of the water on the oysters, i.e., the absorption of water by the

oysters and the loss of salt and solids, is about twice as rapid as when oysters are in contact with still or unagitated fresh water. In computing a reasonable time that oysters may be in contact with fresh water after removal from the shucking pail, allowances should be made for the time necessary to prepare the oysters for washing, by blowing or otherwise, the actual washing time, and the time necessary to transfer the oysters to the skimmer for draining. The total time of contact with fresh water after the oysters are removed from the shuckers' pails until draining commences need not exceed 20 minutes and is usually much less. Since the reaction of oysters with fresh water is about twice as rapid when the oysters are being agitated as when still, the length of time of contact with fresh water during which oysters are agitated should be doubled when computing a reasonable time limit for preventing unnecessary abuse of oysters.

Where the container into which oysters are shucked contains no more fresh water than 1/4 of the capacity of the container, and it is filled with oysters by the shucker, the composition of the water is rapidly altered by material which exudes from the oysters and the absorption of water is not excessive. It is reasonable to place this limit on the amount of water in the shucking containers.

All oysters exude some fluid after removal from the shell. This is called bleeding. This fluid is practically all water. Shucked oysters, even of the same species and grown in the same geographical area when subjected to the same or similar conditions, do not always react in the same way. The differences manifest themselves in many ways, among them the amount of bleeding, the length of time of bleeding, the amount of water absorbed when placed in fresh water, and the amount of soluble material and nutrients lost when placed in fresh water. Oysters in some sections of the country, particularly in certain sections of the Gulf area, bleed more freely and for longer periods of time than oysters from other sections of the country. If oysters be washed, drained, and packed while still bleeding, liquid will appear in the container in which packed giving the appearance of inadequate drainage.

Failure to drain the oysters properly after washing is the principal cause which results in the inclusion of extraneous and unnecessary water in the packed oyster. Adequate drainage is accompanied by permitting the oysters to drain on a skimmer or other perforated surface for a sufficient time. The oysters should be distributed evenly over the surface. The draining area should not be less than 300 square inches per gallon of oysters drained and the perforations should be at least 1/4 inch in diameter and not more than 1 1/4 inches apart. Adequate drainage may be determined objectively by measuring the amount of liquid remaining in the packed oysters. When such oysters contain not more than 5 percent liquid when tested within 15 minutes after packing by the following method they may be considered to have been adequately drained: Take at least a gallon of oysters and obtain weight; drain these oysters for 2 minutes on a skimmer of the dimensions and in the manner just described; remove and weigh drained oysters and calculate weight lost as percentage of weight before draining. An alternative requirement applicable to oysters which bleed for long periods of time is to require that they be drained for not less than five minutes after the last washing with fresh water.

Shucked oysters shrink when placed in contact with water of a higher degree of salinity than the water in which they were grown. There is no known formula by which the amount of shrinkage or absorption can be determined. The salinity of the water in which oysters grow varies from approximately 2 to 32 parts per thousand (. 2 to 3. 2 percent salt). If water in containers into which oysters are shucked or in which oysters are washed contains not less than . 75 percent salt no appreciable loss of solids or absorption of water is likely to occur.

Names and Sizes of Oysters: In the United States oysters are taken commercially from the salty coastal waters and bays of nineteen states on the Atlantic, Gulf and Pacific coasts. The oysters found along the Atlantic and Gulf coasts belong to the species Ostrea virginica and are commonly called oysters, and in some areas "Eastern oysters." The oysters grown along the Pacific coast belong to one of two species: Ostrea lurida, commonly called Olympia oysters, and Ostrea gigas, now commonly called Pacific oysters. From the consumers' standpoint the most significant difference between oysters of these species is their size. The range of sizes of the shucked oysters of the three species is as follows:

Species:	Approximate number of oyster Meats per gallon
O. lurida	1,600 - 2,400
O. virginica	150 - 600
O. gigas	140 - 160

Within recent years increasing amounts of raw oysters of all species have been packed in hermetically sealed containers for direct sale to consumers. Some confusion has arisen on the part of consumers due to the similarity of such containers to those used for canned oysters which are processed by heat. Oysters not processed by heat require constant refrigeration to prevent spoilage while those which are processed by heat in sealed containers require no refrigeration.

With few exceptions shucked oysters, other than Olympia oysters, are separated into size groups. Occasionally the oysters as shucked are of such uniform size that no separation is made. In either case prices are based on size as measured by the number of oyster meats required to fill a gallon container. The price of Eastern oysters increases with the size. Several years ago the oyster industry suggested certain descriptive names synonymous with trade size designations for Eastern Oysters but such descriptive names have not been used to any significant extent. Reasonable ranges of count per gallon, the corresponding trade terms for such sizes, and self-explanatory descriptive names are as follows:

Trade name	Descriptive name	Count per gallon
Counts or plants	Extra large	Not more than 160
Extra selects	Large	161 - 210
Selects	Medium	211 - 300
Standards	Small	301 - 500
Standards	Very small	Over 500

It is in the interest of consumers to have oysters of a designated size classification of approximately the same size. To assure uniformity of size of Eastern oysters it is reasonable to require that a quart measure which is filled by selecting the largest oysters from a representative gallon contain not less than 22.5 percent of the minimum number of oysters permitted in such gallon, and that a quart measure which is filled by selecting the smallest oysters contain not more than 27.5 percent of the maximum number of oysters permitted in such gallon.

The designation of Pacific oysters by the number per pint or pound has become common practice for identifying them as to size. The designations now in common use for the various size classifications of Pacific oysters are as follows:

Count per gallon	Designation.
40 to 64	5 to 8 per pint.
65 to 80	8 to 10 per pint.
81 to 96	10 to 12 per pint.
97 to 120	12 to 15 per pint.
121 to 144	15 to 18 per pint.
More than 144	Over 18 per pint.

It is desirable that in a particular size designation the oysters be comparable in size or approximately the same size. To assure uniformity of size of Pacific oysters it is reasonable to require that the largest oyster in the container be no more than twice the weight of the smallest oyster therein. Shucked Olympia oysters are much smaller than the Eastern and are not segregated for size.

Definitions and Standards of Identity, Quality, and Fill of Container for Raw Oysters: On the basis of the above, and by virtue of the authority vested in the Federal Security Administrator by provisions of the Federal Food, Drug and Cosmetic Act (Section 401: Definitions and Standards for Food, and Section 701: Regulations and Hearings), the following definitions, standards of identity, quality, and fill of container were promulgated on July 3, 1946 to become effective

Oysters, raw oysters, shucked oysters; identity.

(a) Oysters, raw oysters, shucked oysters, are the class of foods each of which is obtained by shucking shell oysters and preparing them in accordance with the procedure prescribed in paragraph (b) of this section. The name of each such food is the name specified in the applicable definition and standard of identity prescribed in the subsequent sections.

(b) If water, or salt water containing less than 0.75 percent salt, be used in any vessel into which the oysters are shucked, the combined volume of oysters and liquid when such oysters are emptied from such vessel is not less than four times the volume of such water or salt water. Any liquid accumulated with the oysters is removed. The oysters are washed, by blowing or otherwise, in water or salt water, or both. The total time that the oysters are in contact with water or salt water after leaving the shucker, including the time of washing, rinsing, and any other contact with water or salt water is not more than thirty minutes. In computing the time of contact with water or salt water, the length of time that oysters are in contact with water or salt water that is agitated by blowing or otherwise, shall be calculated at twice its actual length. Any period of time that oysters are in contact with salt water containing not less than 0.75 percent salt before contact with oysters, shall not be included in computing the time that the oysters are in contact with water or salt water. Before packing into the containers for shipment or other delivery for consumption the oysters are thoroughly drained and are packed without any added substance.

(c) For the purpose of this section:

1. "Shell oysters" means live oysters of any of the species, Ostrea virginica, Ostrea gigas, Ostrea lurida, in the shell, which after removal from the beds, have not been floated or otherwise held under conditions which result in the addition of water.

2. "Thoroughly drained" means one of the following:

(i) The oysters are drained on a strainer or skimmer which has an area of not less than 300 square inches per gallon of oysters drained, and has perforations of at least 1/4 of an inch in diameter and not more than 1 1/4 inches apart, or perforations of equivalent areas and distribution. The oysters are distributed evenly over the draining surface of the skimmer and drained for not less than five minutes; or

(ii) The oysters are drained by any method other than that prescribed by sub-division (i) of this subparagraph whereby liquid from the oysters is removed so that when the oysters are tested within 15 minutes after packing by draining a representative gallon of oysters on a skimmer of the dimensions and in the manner described in subdivision (i) of this subparagraph for two minutes, not more than 5 percent of liquid by weight is removed by such draining.

Extra long oysters, oysters counts (or plants), extra large raw oysters, raw oysters counts (or plants), extra large shucked oysters, shucked oysters counts (or plants) are of the species Ostrea virginica and conform to the definition and standard of identity prescribed for oysters and are of such size that one gallon contains not more than 160 oysters and a quart of the smallest oysters selected therefrom contains not more than 44 oysters.

Large oysters, oysters extra selects, large raw oysters, raw oysters extra selects, large shucked oysters, shucked oysters extra selects are of the species Ostrea virginica and conform to the definition and standard of identity prescribed for oysters and are of such size that one gallon contains more than 160 oysters but not more than 210 oysters; a quart of the smallest selected therefrom contain not more than 58 oysters, and a quart of the largest oysters selected therefrom contains more than 36 oysters.

Medium oysters, oysters selects, medium raw oysters, raw oysters selects, medium shucked oysters, shucked oysters selects are of the species Ostrea virginica and conform to the definition and standard of identity prescribed for oysters and are of such size that one gallon contains more than 210 oysters, but not more than 300 oysters; a quart of the smallest oysters selected therefrom contains not more than 83 oysters, and a quart of the largest oysters selected therefrom

more than 46 oysters.

Small oysters, oysters standards, small raw oysters, raw oysters standards, small shucked oysters, shucked oysters selects are of the species Ostrea virginica and conform to the definition and standard of identity prescribed for oysters and are of such size that one gallon contains more than 300 oysters but not more than 500 oysters; a quart of the smallest oysters selected therefrom contains not more than 138 oysters and a quart of the largest oysters selected therefrom contains more than 68 oysters.

Very small oysters, very small raw oysters, very small shucked oysters are of the species Ostrea virginica and conform to the definition and standard of identity prescribed for oysters and are of such size that one gallon contains more than 500 oysters, and a quart of the largest oysters selected therefrom contains more than 112 oysters.

Olympia oysters, raw Olympia oysters, shucked Olympia oysters are of the species Ostrea lurida and conform to the definition and standard of identity prescribed for oysters.

Pacific oysters size 5 to 8 per pint, raw Pacific oysters size 5 to 8 per pint, shucked Pacific oysters size 5 to 8 per pint are of the species Ostrea gigas and conform to the definition and standard of identity prescribed for oysters and are of such size that one gallon contains less than 65 oysters and the largest oyster in the container is not more than twice the weight of the smallest oyster therein.

Pacific oysters size 8 to 10 per pint, raw Pacific oysters size 8 to 10 per pint, shucked Pacific oysters size 8 to 10 per pint are of the species Ostrea gigas and conform to the definition and standard of identity prescribed for oysters and are of such size that one gallon contains more than 64 and not more than 80 oysters, and the largest oyster in the container is not more than twice the weight of the smallest oyster therein.

Pacific oysters size 10 to 12 per pint, raw Pacific oysters size 10 to 12 per pint, shucked Pacific oysters size 10 to 12 per pint are of the species Ostrea gigas and conform to the definition and standard of identity prescribed for oysters and are of such size that one gallon contains more than 80 and not more than 96 oysters, and the largest oyster in the container is not more than twice the weight of the smallest oyster therein.

Pacific oysters size 12 to 15 per pint, raw Pacific oysters size 12 to 15 per pint, shucked Pacific oysters size 12 to 15 per pint are of the species Ostrea gigas and conform to the definition and standard of identity prescribed for oysters and are of such size that one gallon contains more than 96 and not more than 120 oysters, and the largest oyster in the container is not more than twice the weight of the smallest oyster.

Pacific oysters size 15 to 18 per pint, raw Pacific oysters size 15 to 18 per pint, shucked Pacific oysters 15 to 18 per pint are of the species Ostrea gigas and conform to the definition and standard of identity prescribed for oysters and are of such size that one gallon contains more than 120 and not more than 144 oysters, and the largest oyster in the container is not more than twice the weight of the smallest oyster therein.

Pacific oysters size over 18 per pint, raw Pacific oysters size over 18 per pint, shucked Pacific oysters size over 18 per pint are of the species Ostrea gigas and conform to the definition and standard of identity prescribed for oysters and are of such size that one gallon contains more than 144 oysters and the largest oyster in the container is not more than twice the weight of the smallest oyster therein.

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Other Shellfish:

Mussels especially, and sometimes clams from the Pacific Coast may cause poisoning which results from these shellfish consuming as food the plankton, gonyaulax. This occurs particularly in the summer months. It has been reported that a quarter of an ounce of sodium bicarbonate per quart of water used in cooking mussels will destroy about 80% of this poison in 20 to 30 minutes. Mussels may harbor pathogenic bacteria, such as the Salmonella group, and cause "mussel poisoning." Experiments have shown that when mussels are placed in cold water and heated

to boiling for three minutes, they are safe. Dodgson believes that purification in tanks is the only safe method of handling them. He outlined* the mussel purification process (Conway system) used in England: The polluted mussels are spread, about two deep, on grids, and are hosed with a jet of water (about 130 lb. per square inch pressure) to remove adherent materials from the shells. The mussels are put into tanks of water sterilized by chlorine and neutralized by sodium thiosulphate (mussels will not open their shells and cleanse themselves in presence of 5 ppm. of chlorine). They remain in this bath for 24 hours; then the water is drained off and they are subjected to a second bath in sterile dechlorinated water for a second 24 hours. After this they are hosed. They are then covered for an hour with sterile sea water containing 3 ppm. of available chlorine to sterilize the outside of the shells. Then they are packed into sacks sterilized by 1:1000 chlorine solution.

Shellfish Sampling: A sample of oysters, clams or mussels consists of 10 or more randomly picked from a lot. They should be of average size, have deep bowls, short unbroken lips and shells should be tightly closed. Samples are shipped to the laboratory in canvas bags or other suitable sterilized watertight containers. The containers should be marked for identification and the same mark should be placed in its proper place on the descriptive form which accompanies the sample. All shellfish for bacteriological examination should be handled aseptically. Samples should be kept at or below 10° C. (50° F.) until examined, but under no condition should they be permitted to come in direct contact with ice. Samples of shell oysters should preferably be tested within 12 hours from the time of collection and in no case should samples which have been held more than 30 hours be tested.

Samples of shucked shellfish consist of at least 1/2 pint of shellfish meats removed from the lot by a sterile ladle, after thorough mixing, and placed in a sterile wide mouthed jar. The jar is tightly stoppered. Such samples should be analyzed within 4 hours after collection, if possible. At all times should the samples be kept at or below 50° F.

Crustaceans

Fresh crabs, shrimps, and lobsters furnish particularly favorable media for bacterial growth. When cooked, crustacean meat is sterile or nearly so. Any bacterial growth usually represents contamination by handling. As with shellfish, coliform contamination is a good criterion of the degree of cleanliness and refrigeration in the plant operation and in the shipment, and also the degree of dangerousness to health. The process of decomposition is the same as in other seafood. It has been shown that the boiling time for crabs and lobsters can be reduced by floating contaminated crabs and lobsters for 24 to 48 hours in sea water containing 0.5 ppm. of chlorine.

Crabs have also been incriminated as the cause of poisoning resulting from their consumption of the plankton, gonyaulax.

The development in the preservation of crab meat by pasteurization may lead to important changes in production of this food. It has been pointed out that crab meat which has been pasteurized at 145 degrees F. for 30 minutes, or 150 degrees F. for 20 minutes, or 155 degrees F. for 15 minutes, or 160 degrees F. for 10 minutes, or 170 degrees F. for 1 minute, kept as long as 5 weeks with no evidence of spoilage and with only a small number of bacteria present at the end of that period. After pasteurization the crab meat was stored at a temperature of 41 to 43 degrees F.

The sanitary requirements of all seafoods should be strictly observed always remembering that freshness is associated with:

1. Firmness of tissues.
2. Glossiness of outer covering.
3. Freshness of color.
4. Absence of abnormal odors and slime.

The blackened discoloration of canned lobster meat has been largely eliminated by the use of cans lined with C-enamel.

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*British Medical Journal, July 25, 1936, p. 169-174.

The fundamentals of the detailed sanitary practices for control of seafoods are the same or very similar for all types of seafoods. But because various seafoods have their differences as well as their similarities, there are certain special operations and requirements which are different for fish, shellfish, and crustacean control. The following recommendations for shellfish control were developed by the United States Public Health Service and revised from time to time.

Manual of Recommended Practice for Sanitary Control of the Shellfish Industry

Introduction

The manual of Recommended Practice for Sanitary Control of the Shellfish Industry is the guide by which the shellfish industry in the United States operates. It is given almost entirely below as published in the U.S. Public Health Service Publication No. 33 (with 1964 revisions).

In 1925 State and local health authorities and representatives of the shellfish industry requested the Public Health Service to exercise supervision over the sanitary quality of shellfish shipped in interstate commerce. In accordance with this request, a cooperative control procedure was developed. In carrying out this cooperative control, the States, the shellfish industry, and the Public Health Service each accepted responsibility for certain procedures as follows:

1. Procedures to be Followed by the State. Each shellfish-shipping State adopts adequate laws and regulations for sanitary control of the shellfish industry, makes sanitary and bacteriological surveys of growing areas, delineates and patrols restricted areas, inspects shellfish plants, and conducts such additional inspections, laboratory investigations, and control measures as may be necessary to insure that the shellfish reaching the consumer have been grown, harvested, and processed in a sanitary manner. The State annually issues numbered certificates to shellfish dealers who comply with the agreed-upon sanitary standards, and forwards copies of the interstate certificates to the Public Health Service.

2. Procedures to be Followed by the Public Health Service. The Public Health Service makes an annual review of each State's control program including the inspection of a representative number of shellfish-processing plants. On the basis of the information thus obtained, the Public Health Service either endorses or withholds endorsement of the respective State control programs. For the information of health authorities and others concerned, the Public Health Service publishes a semimonthly list of all valid interstate shellfish-shipper certificates issued by the State shellfish-control authorities.

3. Procedures to be Followed by the Industry. The Shellfish industry cooperates by obtaining shellfish from safe sources, by providing plants which meet the agreed-upon sanitary standards, by maintaining sanitary plant conditions, by placing the proper certificate number on each package of shellfish, and by keeping and making available to the control authorities records which show the origin and disposition of all shellfish.

The fundamental components of this cooperative State-Industry-PHS shellfish certification program were first described in a Supplement to Public Health Reports, "Report of Committee on Sanitary Control of the Shellfish Industry in the United States" (1925). This guide for sanitary control of the shellfish industry was revised and reissued in 1937 and again in 1946. It was separated into two parts by publication of Part II, Sanitation of the Harvesting and Processing of Shellfish in 1957, and by publication in 1959, of Part I, Sanitation of Shellfish Growing Areas. The need for a specialized program of this nature was reaffirmed at the National Conference on Shellfish Sanitation held in Washington, D. C. in 1954 and at the Shellfish Sanitation Workshops held in 1956, 1958, 1961, and 1964.

This edition of the shellfish sanitation manual has been prepared in cooperation with the State shellfish control authorities in all coastal States, food control authorities in the inland States, interested Federal agencies, Canadian Federal departments, the Oyster Institute of North America, the Pacific Coast Oyster Growers Association, and the Oyster Growers and Dealers Association of North America.

Since the growing and processing of shellfish are two distinct phases of operation in the

shellfish industry, the manual has been prepared in two parts: I: Sanitation of Shellfish-Growing Areas; and II: Sanitation of the Harvesting and Processing of Shellfish. Part I of the manual is intended as a guide for the preparation of State shellfish sanitation laws and regulations and for sanitary control of the growing, relaying, and purification of shellfish. Part II is also intended as a guide in the preparation of State laws and regulations, but also for controlling (1) the harvesting and processing of shellfish for shipment in interstate commerce, (2) the shellfish industry in the maintenance of sanitary conditions during harvesting and processing of shellfish, and (3) persons who are responsible for evaluating and supervising sanitary conditions in the harvesting, shucking, processing, packing, and shipping of shellfish.

Part I

Definitions

And/or. Where this term is used, and shall apply where possible; otherwise, or shall apply.

Approved area. An area which has been approved by the State control agencies for growing and/or harvesting of shellfish for direct marketing.

Area, growing. An area in which market Shellfish are grown.

Classes of shippers. (a) Reshippers are shippers who transship shucked stock in original containers, or shell stock, from certified shellfish shippers to other dealers or to final consumers. (Reshippers are not authorized to shuck or repack shellfish.)

(b) Repackers are shippers, other than the original shucker, who pack shucked shellfish into containers for delivery to the consumer. Shippers classified as repackers may shuck shellfish if they have the necessary facilities. A repacker may also act as a shell-stock shipper if he has the necessary facilities.

(c) Shell-stock shippers are shippers who grow, harvest, buy, and/or sell shell stock. They are not authorized to shuck shellfish nor to repack shucked shellfish.

(d) Shucker-packers are shippers who shuck and pack shellfish. A shucker-packer may act as a shell-stock dealer. (Shucker-packers are classified as repackers if shucked shellfish be regularly repacked.)

Coliform group. The coliform group includes all of the aerobic and facultative anaerobic, Gram-negative, non-spore-forming bacilli which ferment lactose with gas formation within 48 hours at 35°C. Bacteria of this group which will produce gas from E. C. medium within 48 hours at 44.5°C. in a water bath will be referred to as fecal coliforms.

Controlled purification. The process of removing contamination from whole live shellfish acquired while growing in polluted areas.

Cooperative program. The cooperative State-PHS-Industry program for the certification of interstate shellfish shippers as described in Public Health Service Publication Number 33, Manual of Recommended Practice for Sanitary Control of the Shellfish Industry, Parts I and II.

Depletion. The removal of all market-size shellfish from an area.

Dry storage. The storage of all shell stock out of water.

Food-product zone. The parts of food equipment, including auxiliary equipment (such as blower pipes and drain valves), which may be in contact with the food being processed, or which may drain into the portion of equipment with which food is in contact.

Internal temperature. Actual temperature of shucked shellfish in the container, as opposed to the air temperature of the refrigerator in which the shellfish may be stored.

Most probable number (abbreviated MPN). The MPN is a statistical estimate of the number of bacteria per unit volume, and is determined from the number of positive results in a series of fermentation tubes. A complete discussion of MPN determinations and computations, including MPN tables, can be found in the American Public Health Association publication "Standard

Methods for the Examination of Water, Sewage, and Industrial Wastes."

Population equivalent (coliform). A quantity of sewage containing approximately 150×10^9 coliform group bacteria. This is approximately equal to the per capita per day contribution of coliforms as determined in a metropolitan sewerage system.

Sanitation Survey. The sanitary survey is the evaluation of all factors having a bearing on the sanitary quality of a shellfish growing area including sources of pollution, the effects of wind, tides, and currents on the distribution and dilution of the polluting materials, and the bacteriological quality of the water.

Shellfish. All edible species of oysters, clams, or mussels. Shellfish products which contain any material other than the meats and/or shell liquor of oysters, clams, or mussels will be regarded as a "processed food" and will not be included in the cooperative program.

Shellfish, market. Shellfish which are, may be, or have been harvested and/or prepared for sale for human consumption as a fresh or frozen product.

Shell stock. Shellfish which remain in their shells.

State shellfish control agency. The State agency or agencies having legal authority to classify shellfish growing areas and/or to issue permits for the interstate shipment of shellfish in accord with the provisions of this manual.

State shellfish patrol agency. The State agency having responsibility for the patrol of shellfish growing areas.

Shucked shellfish. Shellfish, or parts thereof, which have been removed from their shells.

Transplanting. The moving of shellfish from one area to another area.

Wet storage. The temporary storage of shellfish from approved sources, intended for marketing, in tanks containing sea water or in natural bodies of water, and including storage in floats.

Section A

General Administrative Procedures

1. State Laws and Regulations. State laws or regulations shall provide an adequate legal basis for sanitary control of all interstate phases of the shellfish industry. This legal authority shall enable one or more departments or agencies of the State to classify shellfish growing areas on the basis of sanitary quality, effectively regulate the harvesting of shellfish; effectively prosecute persons apprehended harvesting shellfish from restricted, prohibited, or nonapproved areas; regulate and supervise the shipment and storage of shell stock, and the shucking, packing, and repacking of shellfish; make laboratory examinations of shellfish; seize, condemn, or embargo shellfish; and restrict the harvesting of shellfish from particular areas and suspend interstate shipper certificates in public-health emergencies.

Sanitary compliance. This item will be satisfied when the State has legal authority to:

a. Classify actual and potential shellfish growing areas on the basis of sanitary quality as defined in section C of this manual. (It is strongly recommended that a State permit be required for the growing or harvesting of shellfish, and that such permits be revocable or subject to suspension for just cause. It is also recommended that the State have authority to regulate the discharge of sewage, radioactive, and other toxic wastes from boats in the vicinity of approved shellfish growing areas.)

b. Control the harvesting of shellfish from areas which are contaminated or which contain paralytic shellfish poison. To be effective, this authority must allow the State to:

(1) Patrol growing areas,
(2) Apprehend persons violating the restrictions,
(3) Effectively prosecute persons apprehended harvesting shellfish from restricted or

prohibited areas. (Penalties for such violations should be sufficient to discourage illegal harvesting.)

c. Regulate and supervise relaying, depletion, wet storage, and controlled purification as described in this manual if these techniques be used.

d. Require that shell stock in storage or in transit from the growing area to the certified shipper be protected against contamination; i.e., every person, firm, or corporation that handles shellfish up to the certified shipper will be subject to sanitary control by an official agency but will not necessarily be required to have a State shellfish permit.

e. Prohibit Cooperative Program shippers from possessing or selling shellfish from out-of-state sources unless such shellfish have been produced in accord with Cooperative Program requirements.

f. Regulate the operations of shucker-packers, repackers, shell stock shippers and reshippers in accord with the applicable provisions of part II of this manual.

g. Restrict the harvesting of shellfish from specific areas, and suspend interstate shipper certificates in a public-health emergency. Administrative procedures required in connection with such emergency actions should not require more than one day to complete.

h. Prevent the sale, shipment, or possession of shellfish which cannot be identified as having been produced in accord with Cooperative Program requirements or which are otherwise unfit for human consumption, and to condemn, seize, or embargo such shellfish. This authority need not be specific for shellfish and may be included in other State food laws.

Public-health explanation. The Cooperative Program was developed by the 1925 Conference on Shellfish Pollution to meet the specific public-health need resulting from the 1924-25 typhoid epidemic.

However, the Cooperative Program has gone beyond the original objective of insuring that shellfish shipped interstate would not be the cause of communicable disease. Thus, in the 1940's, paralytic shellfish poison became a matter of public-health concern and steps were taken to protect the public against this hazard. In 1957 it was recognized that shellfish might concentrate certain radionuclides and that a radiation surveillance activity might become a necessary adjunct to the established procedures.

To accomplish these public-health objectives the State must supervise all phases of the growing, harvesting, transportation, shucking-packing and repacking of shellfish to be shipped interstate. It is also important that shellfish be properly refrigerated and protected against contamination during interstate shipment. This is not easily accomplished by the State of origin although certified shippers are required to pack shellfish in containers which will protect them against contamination.

If State supervision be effective, all phases of the activity must be supported by legal authority. This authority may be either a specific law or regulation. The success with which the State is able to regulate the several components of the shellfish industry provides a measure of the adequacy of the statutory authority.

The unique nature of shellfish as a food also makes it necessary that the State shellfish control agency have authority to take immediate emergency action to halt harvesting or processing of shellfish without recourse to lengthy administrative procedures.

Periodic revisions of State shellfish laws or regulations may be necessary to cope with new public-health hazards and to reflect new knowledge.

Experience has demonstrated that actual and potential shellfish growing areas of the State must be classified as to their sanitary suitability for shellfish harvesting. Harvesting should be permitted only from those areas which have been found by sanitary survey to meet the sanitary criteria of this manual. Harvesting should accordingly be specifically prohibited from areas which do not meet the criteria, or which have not been surveyed.

2. General Administrative Procedures to be Used by States. States shall keep records which will facilitate Public Health Service review of their shellfish sanitation programs and

shall assist the Service in making such reviews. States shall not certify shippers for interstate shipment unless the shipper complies substantially with the construction requirements of Part II of this manual and maintains a sanitation rating of at least 80 percent during periods of operation.

Shippers not meeting these requirements will not be eligible for inclusion on the Public Health Service list of State certified shellfish shippers. Cooperative Program standards shall be applied to all growing areas, all shellfish harvesters, and all persons handling shell stock prior to its delivery to the Cooperative Program certified shipper. When two or more State agencies are involved in the Sanitary control of the shellfish industry, a clear statement of responsibility of each agency should be developed.

Satisfactory compliance. This item will be satisfied when:

a. Cooperative Program requirements are applied to all market-shellfish harvesters.

b. Cooperative Program requirements are applied to all commercial market shellfish harvesters.

c. Cooperative Program requirements are applied to all persons handling the shellfish prior to its delivery to the interstate shipper.

d. Interstate shellfish shipper certificates are issued only to those establishments substantially meeting the construction requirements of part II of this manual and which maintain a plant sanitation rating of at least 80 percent during periods of operations. (The State shellfish control agency shall suspend or revoke certificates if a plant sanitation rating drops below 80 percent or if an individual sanitation item be violated repeatedly.) Ratings will be determined on the basis of compliance with the applicable provisions of part II of this manual as measured by an inspection report comparable to that contained in Appendix A of Part II.

e. The following records are kept of shellfish sanitation activities as required in section C, D, and E, part I, of this manual, and when monthly summaries of State patrol activities are forwarded to the Public Health Service regional office:

(1) Individual growing area files. (Areas may be defined by either geographic or political boundaries.)

(2) Patrol activities, including arrests, prosecutions, and the results of prosecutions.

(3) Plant inspections. Shucker-packers and repackers shall ordinarily be inspected at least monthly. Shell stock shippers and reshippers shall be inspected at a frequency which will afford adequate public-health supervision of their operations. A central inspection-report file should be maintained by the State.

f. The following guidelines are observed by the State in issuing interstate shellfish shipper certificates.

(1) Certificate content. Each certificate should give the following information:

Name. (The usual business name and alternative names that should appear on the interstate shellfish shippers list, hereafter called "list").

Address. (A business and/or mailing address in the State issuing the certificate. This address indicates where records are kept and where inspection may be arranged.)

Certificate Number. (A number shall be assigned for each business unit. Suffix or prefix letters may not be used to differentiate between two or more plants of a given shipper.)

Classification. (The shipper classification should be indicated by a symbol: i.e., shucker-packer, SP; repacker, RO; shell stock, SS; or reshipper, RS. Only one classification should be used. The single classification will cover all proposed operations which the shipper is qualified to perform.)

Expiration Date. (All certificates in a State should expire on the same date, preferably the last day of a month. This date will be shown on the "list". All certificates will be automatically withdrawn from the "list" on the date of expiration unless new certificates have been received by Public Health Service headquarters office. If the date of expiration coincides with the date of issue for the "list" the certificates expiring on the date of issue will be deleted.)

Certifying Officer. (Each certificate is signed by a responsible State official.)

(2) Certificate changes. A change in an existing, unexpired certificate should be made by issuing a corrected certificate.

(3) Interstate shipment before listing. The shipper should be informed of the prob-

able dates his name will appear on the "list" and should be advised against making interstate shipment prior to that date. (If shipments must be made before the appearance of the shipper's name on the "list," the Public Health Service will notify the applicable receiving States if the names and addresses of the expected receivers are indicated in advance by the State when the certificate is forwarded to the Public Health Service.)

(4) State cancellation, revocation or suspension of interstate shipper certificates. If a State revokes, cancels, or suspends an interstate shellfish shipper certificate, the Public Health Service regional office should be immediately notified, preferably by telephone or telegram with a following confirmatory letter.

(5) Mailing list for interstate shellfish shipper list. Names of persons, business units, organizations, or agencies, desiring copies of the "list," and requests for information concerning the "list" should be sent to the appropriate Public Health Service regional office. Recipients will be circularized periodically to determine if they still have use for the "list".

g. The appropriate Public Health Service regional office is notified by the State of any revision in growing area classification. The notification shall so describe the area that it may be readily located on Coast and Geodetic Survey charts.

h. State shellfish plant inspectors are provided with the following inspection equipment: standardized inspection forms, thermometer, chlorine test kit, and light meter.

i. Interdepartmental memoranda of understanding have been developed which will define the responsibilities of each State agency in maintaining adequate sanitary control of the shellfish industry in the State.

Public-health explanation. The annual review of each participating State's shellfish sanitation activities is a fundamental Public Health Service responsibility in the Cooperative Program. The purpose of this review is to evaluate the adequacy and reliability of each individual State program in accord with the agreed-upon standards. The Service will endorse those State programs meeting the Cooperative Program standards and will publish and distribute a list of the names of the State certified shippers. However, if a State program does not meet the standards, the program will not be endorsed. Names of nonparticipating States will be omitted from the Public Health Service list of State certified shellfish shippers.

Minimum plant sanitation standards for interstate shellfish shippers are described in part II of this manual. Experience has shown that absolute compliance with these minimum standards is not always attainable, particularly those items which relate to operating procedures. The establishment of the 90 percent plant sanitation score as a prerequisite for listing on the Public Health Service list of State certified shellfish shippers recognizes the fact that perfection is not always obtainable, and, at the same time, provides a mechanism for excluding any plant which is not operated in a reasonably sanitary manner.

Cooperative program sanitary requirements should be applied to all growing areas and all shellfish harvesters to insure that all shellfish available to certified dealers have been produced and harvested under acceptable sanitary conditions. It is also important that the shell stock be protected against contamination during the period between harvesting and delivery to the certified shipper.

3. Intrastate Sale of Market Shellfish. Sanitary standards for intrastate shellfish shippers should be substantially equivalent to those of the Cooperative Program.

Public-health explanation. States may accept lower sanitary standards for shellfish sold intrastate than are required by the Cooperative Program. However, it has been found that small intrastate shippers may at times sell their product to interstate shippers if demand exceeds the supply of shellfish available to the latter. Because of the possibility that such substandard shellfish might be shipped interstate, the 1954 National Conference on Shellfish Sanitation recommended that Cooperative Program standards be applied to all shellfish production and processing.

The 1958 Shellfish Sanitation Workshop also strongly recommended the use of substantially equivalent standards for intra and inter-state shellfish shippers.

Section B

Laboratory Procedures

1. Bacteriological. American Public Health Association Standard Methods shall be followed in the collection and transportation of samples of shellfish and shellfish waters for bacteriological examination and in the laboratory examination of such samples.[1]

Satisfactory compliance. This item will be satisfied when current APHA recommended procedures for the examination of sea water and shellfish are followed in the bacteriological examination of shellfish and shellfish waters.

Public-health explanation. Experience with the bacteriological examination of shellfish and shellfish growing waters has indicated that minor differences in laboratory procedures or techniques will cause wide variations in the results. Variations in results may also be caused by improper handling of the sample during collection or transportation to the laboratory. The APHA recommended procedures for the examination of sea water and shellfish, which are revised periodically, offer a reliable way of minimizing these variations.

2. Toxicological. A recognized procedure shall be used in the assay for paralytic shellfish poison.

Satisfactory compliance. This item will be satisfied when current Association of Official Agricultural Chemists official methods are followed in the bioassay for paralytic shellfish poison.

Public-health explanation. If reliable results are to be obtained, it is essential that the test procedures be standardized and that variations due to use of strains of mice be minimized. The official procedure for the bioassay for paralytic shellfish poison adopted by the Association of Official Agricultural Chemists minimizes these variations. A chemical test for paralytic shellfish poison has also been developed.[2]

3. Chemical and Physical. Standard laboratory methods shall be used for all salinity, radionuclide, and other chemical and physical determinations made on shellfish or shellfish waters in conjunction with Cooperative Program activities. Results shall be reported in standard units.

Satisfactory compliance. This item will be satisfied when:

a. Chemical and physical measurements on shellfish and shellfish waters are made in accord with accepted laboratory techniques.

b. Results of all chemical and physical determinations are expressed in standard units. (For example, salinity should be expressed in parts per thousand rather than hydrometer readings.)

Public-health explanation. Standardized laboratory procedures are most apt to produce results in which the State shellfish control agency can have confidence, and facilitate comparative evaluation of data. The need for adherence to standardized procedures should not discourage laboratories from experimental use of nonstandard methods.

Section C

Growing Area Survey and Classification

1. Sanitary Surveys of Growing Areas. A sanitary survey shall be made of each growing area prior to its approval by the State as a source of market shellfish or of shellfish to be used in a controlled purification or relaying operation. The sanitary quality of each area shall be reappraised at least biennially and, if necessary, a resurvey made. Ordinarily, resurveys will be much less comprehensive than the original survey since it will only be necessary to bring the original information up to date. Records of all original surveys and resurveys of growing areas shall be maintained by the State shellfish control agency, and shall be made available to Public Health Service review officers upon request.

1. Material which may be useful in interpretation of results of bacteriological examination of shellfish is contained in appendix A, Part 1.

2. McFarren, E. F., et al., Journal of the Association of Official Agricultural Chemists, February, 1958.

Satisfactory compliance. This item will be satisfied when:

a. A sanitary survey has been made of each growing area in the State prior to initial approval of interstate shipments of shellfish from that area. A comprehensive sanitary survey shall include an evaluation of all sources of actual or potential pollution on the estuary and its tributaries, and the distance of such sources from the growing areas; effectiveness and reliability of sewage treatment works; the presence of industrial wastes, pesticides, or radionuclides which would cause a public-health hazard to the consumer of the shellfish; and the effect of wind, stream flow, and tidal currents in distributing polluting materials over the growing area.[3] The thoroughness with which each element must be investigated varies greatly and will be determined by the specific conditions in each growing area.

b. The factors influencing the sanitary quality of each approved shellfish growing area are reappraised at least biennially.[4] A complete resurvey should be made of each growing area in an approved category at least once every ten years; however, data from original surveys can be used when it is clear that such information be still valid.

c. A file which contains all pertinent sanitary survey information, including the dates all results of preceding sanitary surveys is maintained by the State shellfish control agency for each classified shellfish area.

d. The State agency having primary responsibility of this element of the Cooperative Program develops a system for identification of growing area.

Public-Health explanation. The positive relationship between sewage pollution of shellfish growing area and enteric disease has been demonstrated many times. However, epidemiological investigations of shellfish-caused disease outbreaks have never established a direct numerical correlation between the bacteriological quality of water and the degree of hazard to health. Investigations made from 1914 to 1925 by the States and the Public Health Service--a period when disease outbreaks attributable to shellfish were more prevalent--indicated that typhoid fever or other enteric disease would not ordinarily be attributed to shellfish harvested from water in which not more than 50 percent of the one cc. portions of water examined were positive for coliforms,[5] provided the areas were not subject to direct contamination with small amounts of fresh sewage which would not ordinarily be revealed by the bacteriological examination.

Following the oyster-borne typhoid outbreak during the winter of 1924-25 in the United States, the cooperative shellfish certification program was initiated by the States, the Public Health Service, and the shellfish industry. Water quality criteria were then stated as:

a. The area is sufficiently removed from major sources of pollution so that the shellfish would not be subjected to fecal contamination in quantities which might be dangerous to the public health.

b. The area is free from pollution by even small quantities of fresh sewage. The report emphasized that bacteriological examination does not, in itself, offer conclusive proof of the sanitary quality of an area.

c. Bacteriological examination does not ordinarily show the presence of the coli-aerogenes group of bacteria in 1 cc. dilutions of growing area water.

The reliability of this three-part standard for evaluating the safety of shellfish producing areas is evidenced by the fact that no major outbreaks of typhoid fever or other enteric disease have been attributed to shellfish harvested from waters meeting the criteria since they were adopted in the United States in 1925. Similar water quality criteria have been in use in Canada with like results. The available epidemiological and laboratory evidence gives little idea as to the margin of safety, but it is probably considerable as indicated by the virtual absence of

3. In making the sanitary survey, consideration should be given to the hydrographic and geographic characteristics of the estuary, the bacteriological quality of the growing area water and bottom sediments, and the presence and location of small sources of pollution, including boats, which might contribute fresh sewage to the area.

4. The purpose of this reappraisal is to determine if there have been changes in stream flow, sewage treatment, populations, or other similar factors which might result in a change in the sanitary quality of the growing area. The amount of field work associated with such a reappraisal will depend upon the area under consideration and the magnitude of the changes which have have taken place.

5. An MPN of approximately 70 per 100 ml.

reported shellfish caused enteric disease over a comparatively long period of time.

The purpose of the sanitary survey is to identify and evaluate those factors influencing the sanitary quality of a growing area and which may include sources of pollution, potential or actual; the volume of dilution water; the effects of currents, winds and tides in disseminating pollution over the growing areas; the bacterial quality of water and bottom sediments; die-out of polluting bacteria in the tributaries and the estuary; bottom configuration; and salinity and turbidity of the water. Sources of pollution include municipal sewage discharged into the estuary or inflowing rivers; sewage brought into the estuary by tides or currents; surface run-off from polluted areas; industrial wastes; and discharges from pleasure craft, fishing boats, naval vessels, and merchant shipping.

Bacteriological examination of the growing waters is an important component of the sanitary survey. In many instances the bacteriological and related salinity data will also provide valuable information on the hydrographic characteristics of an area.[6, 7]

Ideally, a large number of water samples for bacteriological examination should be collected at each station. However, in most instances this is not practical because of time and budget limitations, and accordingly only a limited number of samples can be collected. Therefore, sampling stations should be chosen which will provide a maximum of data, and which will be representative of the bacteriological quality of water in as wide an area as possible. Sample collection should be timed to represent the most unfavorable hydrographic and pollution conditions since shellfish respond rapidly to an increase in the number of bacteria in their environment.

There is no specified minimum number of sampling stations, frequency of sampling, or total number of samples. Sampling results obtained over a period of several years can be used as a block of data provided at least 15 samples have been collected from each of a representative number of stations along the line separating approved from restricted growing areas and there have been no adverse changes in hydrographic or sanitary conditions. Only occasional bacteriological samples are necessary from areas which are shown to be free from pollution.

Experience with the shellfish certification program indicates a tendency to omit or deemphasize some components of the sanitary survey unless a central State file of all shellfish sanitary surveys, reappraisals, and resurveys be maintained. This is particularly true where responsibility for shellfish sanitation is divided between two or more State agencies. Maintenance of a central State file for all shellfish sanitary survey information will also simplify the endorsement appraisal of State programs by the Public Health Service and will help prevent loss of old data which may be useful in evaluating the sanitary quality of an area.

Periodic reappraisals of the sanitary quality of shellfish producing areas are necessary to determine that environmental conditions are such that the original conclusions are still valid. A resurvey should be made within 1 year if the reappraisal shows a significant detrimental change.

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6. Bacteria in an unfavorable environment die out in such a way that following an initial lag period there is a large percentage decline during the first few days. Descriptions of studies on bacterial die-out have been published by Greenberg, 1956, and Pearson, 1956. Die-off has also been investigated by the Public Health Service Shellfish Sanitation Laboratory at Woods Hole, Mass., and Pensacola, Fla. Application of this principle may be helpful in predicting the quantity of pollution which will reach an area, and in establishing objective effluent quality criteria.

7. In connection with the evaluation of sampling results, it should be noted that MPN determination is not a precise measure of the concentration of bacteria. Thus, in repeated sampling from waters having a uniform density of bacteria, varying MPN estimates will be obtained. The use of the tolerance factor 3.3 (applicable only to 5 tube decimal dilution MPN's is one method of recognizing this variation. For example, in a body of water in which the median concentration of coliform bacteria is 70 per 100 ml., 95% of observed MPN's will be between 20 and 230 per 100 ml.; i.e., $70/3.3 = 21$ and $70 \times 3.3 = 230$.

2. Classification of Growing Areas. All growing areas shall be classified as to their public-health suitability for the harvesting of market shellfish. Classification criteria are described in sections C-3, C-4, C-5, C-6, and C-7 of this manual. Except in emergency, any revision of an area classification shall be preceded by a sanitary survey, resurvey, or reappraisal. A written analysis of the data justifying the reclassification shall be made a part of the area file.[8]

Satisfactory compliance. This item will be satisfied when:

a. All actual and potential shellfish growing areas in the State are correctly designated with one of the following classifications on the basis of sanitary survey information: Approved; conditionally approved; restricted; or prohibited.[9]

b. Area classifications are revised whenever warranted by survey data.

c. Classifications are not revised without at least a file review, and there is a written record of such review in the area file maintained by the State shellfish control agency.

d. All actual and potential shellfish growing areas which have not been subjected to sanitary surveys shall be automatically classified as prohibited.

Public health explanation. The probable presence or absence of pathogenic organisms in shellfish waters is of the greatest importance in deciding how shellfish obtained from an area may be used. Shellfish growing areas should thus be classified according to the information developed in the sanitary survey. Classification should not be revised without careful consideration of available data. Areas should be reclassified whenever warranted by existing data. A written justification for the reclassification simplifies Public Health Service appraisal of State programs.

3. Approved Areas. Growing areas may be designated as approved when: (a) the sanitary survey indicates that pathogenic micro-organisms, radionuclides, and/or harmful industrial wastes do not reach the area in dangerous concentration, and (b) this is verified by laboratory findings insofar as possible. Shellfish may be taken from such area for direct marketing.

Satisfactory compliance. This item will be satisfied when the two following criteria are met:

a. The area is not so contaminated with fecal material, radionuclides, or industrial wastes that consumption of the shellfish might be hazardous. (See section C, item 7, regarding shellfish toxins in shellfish growing areas), and

b. The coliform median MPN of the water does not exceed 70 per 100 ml., and not more than 10 percent of the samples ordinarily exceed an MPN of 230 per 100 ml. for a 5-tube decimal dilution test (or 330 per 100 ml., where the 3-tube decimal test is used) in those portions of the area most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions. (Note: This concentration might be exceeded if less than 8 million cubic feet of a coliform-free dilution water be available for each population equivalent (coliform) of sewage reaching the area.) The foregoing limits need not be applied if it can be shown by detailed study that the coliforms are not of direct fecal origin and do not indicate a public-health hazard.[10]

Public-health explanation. A review of epidemiological investigations of disease outbreaks attributable to the consumption of raw shellfish reveals that two general situations prevail[11] insofar as pollution of growing or storage areas are concerned.

8. States may use other terms or terminology in describing area classification; provided, that the classification terms used be consistent with the intent and meaning of the words "approved," "conditionally approved," "restricted," or "prohibited".

9. Closures may also be based on presence of shellfish toxins.

10. This MPN value is based on a typical ratio of coliforms to pathogens and would not be applicable to any situation in which an abnormally large number of pathogens might be present. Consideration must also be given to the possible presence of industrial or agricultural wastes in which there is an atypical coliform to pathogen ratio.

11. There is a third general consideration in which shellfish may be contaminated through mishandling. This is not related to growing area sanitation and is considered in Part II of this manual.

a. Gross sewage contamination of a growing or wet storage area. (A report of a 1910 outbreak of typhoid fever involving 45 persons notes that raw sewage from a city with a population of 30,000 was discharged only a few hundred feet away from clam beds and floats. In 1947 a case of typhoid fever was attributed to clams harvested 200 yards from the outlet of a municipal sewage treatment plant. In the latter case, the coliform MPN of the harbor water exceeded 12,000 per 100 ml. and the area had been posted as closed to shellfish harvesting.)

b. Chance contamination of a growing or wet storage area by fresh fecal material which may not be diffused throughout the entire area and therefore not readily detectable by ordinary bacteriological procedures. The possibility of chance contamination was noted by Dr. Gurion in his report on a 1902 typhoid outbreak, and who is quoted in Public Health Bulletin No. 86, as "there is a zone of pollution established by the mere fact of the existence of a populated city upon the banks of a stream or tidal estuary which makes the laying down of oysters and clams in these waters a pernicious custom if persisted in, because it renders these articles of food dangerous at times, and always suspicious". The 1956 outbreak of infectious hepatitis in Sweden (691 cases) attributed to oysters which were contaminated in a wet storage area is an example of such contamination. Similarly in 1939, 87 cases of typhoid were attributed to fecal contamination of a storage area by a typhoid carrier.

It is well established that shellfish from water having a median coliform MPN not exceeding 70 per 100 ml. and which is also protected against chance contamination with fecal material, will not be involved in the spread of disease which can be attributed to initial contamination of the shellfish. This is not surprising since a water MPN of 70/100 ml. is equivalent to a dilution ratio of about 8 million cubic feet of coliform-free water per day for the fecal material from each person contributing sewage to the area. This tremendous volume of water is available in shellfish growing areas through tidal action which is constantly bringing unpolluted water into the area.

Areas which are approved for direct market harvesting of shellfish which will be eaten raw must necessarily meet one general test; i.e., sewage reaching the growing area must be so treated, diluted, or aged that it will be of negligible public-health significance. This implies an element of time and distance to permit the mixing of the sewage or fecal material with the very large volume of diluting water and for a major portion of the micro-organisms to die out. Studies of the natural die-off of microorganisms in an unfavorable marine environment have been summarized by Greenberg, 1956.

The effectiveness of sewage treatment processes must be considered in evaluating the sanitary quality of a growing area since the bacterial content of the effluent will be determined by the degree of treatment which is obtained. The results of bacteriological sampling must also be correlated with sewage treatment plant operation, and evaluated in terms of the minimum treatment which can be expected with a realization of the possibility of malfunctioning, overloading, or poor operation.

The presence of radionuclides in growing area waters may also have public-health significance since shellfish, along with other marine organisms, have the ability to concentrate such materials. The degree to which radioisotopes will be concentrated depends upon the species of shellfish and the specific radioisotope. For example, it has been reported that the Eastern oyster has a concentration factor of 17,000 for Zn^{65} whereas the concentration factor for Sr^{89} is approximately unity. The distribution of the radioisotope in the shellfish and the biological half-life are also variable. Sources of radioactive materials include fall-out, industrial wastes, and nuclear reactors. Limiting maximum permissible concentrations of radioactive materials expressed in terms of specific radioisotopes and unidentified mixtures in water and food have been established. The current standard should be consulted in evaluating the public-health significance of detected radioactivity in market shellfish.

The bacterial quality of active shellfish will ordinarily be directly proportional to the bacterial quality of the water in which they grew; however, considerable variation in individual determinations may be expected. The coliform MPN's of the shellfish usually exceed those of the overlying water because shellfish filter large quantities of water to obtain food, thereby concentrating the suspended bacteria. This relationship will depend upon the shellfish species, water temperature, presence of certain chemicals, and varying capabilities of the individual animals.

(See appendix A, Part 1.)

4. Conditionally Approved Areas. The suitability of some areas for harvesting shellfish for direct marketing is dependent upon the attainment of an established performance standard by sewage treatment works discharging effluent, directly or indirectly, to the area. In other cases the sanitary quality of an area may be affected by seasonal population, or sporadic use of a dock or harbor facility. Such areas may be classified as conditionally approved.

State shellfish control agencies shall establish conditionally approved areas only when satisfied that (a) all necessary measures have been taken to insure that performance standards will be met, and (b) that precautions have been taken to assure that shellfish will not be marketed from the areas subsequent to any failure to meet the performance standards and before the shellfish can purify themselves of polluting micro-organisms.

Satisfactory compliance. This item will be satisfied when:

a. The water quality requirements for an approved area are met at all times while the area is approved as a source of shellfish for direct marketing.

b. An operating procedure for each conditionally approved area is developed jointly by the State shellfish control agency, local agencies, including those responsible for operation of sewerage systems, and the local shellfish industry. The operating procedure should be based on an evaluation of each of the potential sources of pollution which may affect the area. The procedures should establish performance standards, specify necessary safety devices and measures, and define inspection and check procedures. (These procedures are described in more detail in the following public-health explanation.)

c. A closed safety zone is established between the conditionally approved area and the source of pollution to give the State agency time to stop shellfish harvesting if performance standards be not met.

d. Boundaries of conditionally approved areas are so marked as to be readily identified by harvesters.

e. Critical sewerage system units are so designed, constructed, and maintained that the chances of failure to meet the established performance standards due to mechanical failure or overloading are minimized.

f. There is a complete understanding of the purpose of the conditionally approved classification by all parties concerned, including the shellfish industry. Successful functioning of the concept is dependent upon the wholehearted cooperation of all interested parties. If such cooperation be not assured the State should not approve the area for direct harvesting of market shellfish.

g. Any failure to meet the performance standards is immediately reported to the State shellfish control agency by telephone or messenger. In some instances States may find it desirable to delegate the authority for closing a conditionally approved area to a representative of the agency located in the immediate area.

h. The State immediately closes conditionally approved areas to shellfish harvesting following a report that the performance standards have not been met. The area shall remain closed until the performance standards can again be met plus a length of time sufficient for the shellfish to purify themselves so that they will not be a hazard to the public health. (See section D-1, "Relaying," for information on the length of time required for self-purification of shellfish.)

i. The State shellfish control agency makes at least two evaluations during the shellfish harvesting season of each conditionally approved area including inspection of each critical unit of the sewerage system to determine the general mechanical condition of the equipment, the accuracy of recording by the operating agency.

j. If it be discovered that failure to meet performance standards have not been reported by the operating agency, or if the performance standards be not met, the area shall immediately revert to a restricted or prohibited classification.

k. All data relating to the operation of a conditionally approved area, including operation of sewerage systems, are maintained in a file by the State shellfish control agency.

Public-health explanation. The conditionally approved classification is designed primarily to protect shellfish growing areas in which the water quality might undergo a significant adverse

change within a short period of time.[12] The change might result from overloading or mechanical failure of a sewage treatment plant, or bypassing of sewage at a lift station.

Water quality in many growing areas in the more densely populated sections of the country is, to some degree, dependent upon the operation of sewage treatment plants. For example, the boundaries of an approved shellfish area might be determined during a period when a tributary sewage treatment plant is operating at a satisfactory level. If there be some interruption in treatment it follows that there will be some degradation of water quality in the growing area, which may justify a relocation of the boundaries. The degree of relocation would depend upon such items as the distance between the pollution source and the growing area, hydrography, the amount of dilution water, and the amount of pollution.

The concept is also applicable to other situations in which there may be a rapid or seasonal change in water quality. Examples of such situations include --

a. A growing area adjacent to a resort community. During the summer months the community might have a large population which might have an adverse effect on water quality.

b. A protected harbor in a sparsely settled area might provide anchorage for a fishing fleet several months a year. When the fishing fleet is in, the harbor water would be of poor sanitary quality.

c. The water quality in an area fluctuates with the discharge of a major river. During periods of high runoff,the area is polluted because of decreased flow time in the river.

The establishment of conditionally approved areas might be considered whenever the potential for sewage contamination is such that the limiting water quality criteria for an approved area might be exceeded in less than one week due to a failure of sewage treatment, or other situations as described above.

The first step in determining whether an area should be placed in the conditionally approved classification is the evaluation of the potential sources of pollution in terms of their effect on water quality in the area. Potential sources of pollution include the following:

(1) Sewage treatment plants.
   (a) By-passing of all or part of sewage because of mechanical or power failure, hydraulic overloading, or treatment overloading.
   (b) Reduced degree of treatment due to operational difficulties or inadequate plant.
(2) Sewage lift stations.
   (a) By-passing during periods of maximum flow due to inadequate capacity.
   (b) By-passing because of mechanical or power failure.
(3) Interceptor sewers or underwater outfalls.
   (a) Exfiltration due to faulty construction.
   (b) Leakage due to damage.
(4) Other sources of pollution.
   (a) Sewage from merchant or naval vessels.
   (b) Sewage from recreation use of area.

The second step in establishment of a conditionally approved area is the evaluation of each source of pollution in terms of the water quality standards to be maintained, and the formulation of performance standards for each installation having a significant effect on the sanitary quality of the area. Examples of performance standards might include:

(1) Bacteriological quality of effluent from sewage treatment plants. This might be stated in terms of chlorine residual if the bacteriological quality of the effluent can be positively related to chlorine residual.

(2) Total quantity of sewage which can be discharged from any given unit, or from a combination of units, without causing the basic water quality standards to be exceeded.

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12. A natural disaster may also cause many sewage treatment plants to be out of service for an extended period of time. The conditionally approved area concept is not ordinarily concerned with such emergency situations.

(3) Amount of shipping in the area and the amount of sewage which can be expected.

Design criteria which may be useful in formulating an opinion on the quantity of sewage which can be discharged into an area without exceeding the desired water quality standards include: Population equivalent (coliform) of sewage, predicted survival of coliform in sea water, effectiveness of chlorination, and the total quantity of clean dilution water in an area. Results of many studies on the survival of bacteria in sea water have been summarized in An Investigation of the Efficacy of Submarine Outfall Disposal of Sewage and Sludge; Publication No. 14, California State Water Pollution Control Board, 1956.

The mechanical equipment at critical sewage treatment or pumping units should be such that interruptions will be minimized. Wherever possible,operations should be automatically recorded on charts. Examples of the requirements which might be imposed, depending upon the importance of the unit in terms of water quality, include:

(1) Ample capacity for storm flows. (Storm water should ordinarily be excluded from the sanitary system.)

(2) Standby equipment to insure that treatment or pumping will not be interrupted because of damage to a single unit or to power failure.

(3) Instrumentation of pumps and equipment to allow the regulatory agency to determine that performance standards have been met. Examples include:

(a) Recording scales to indicate rate of chlorine use. Chlorine flow can be integrated with hydraulic flow to establish a ratio.

(b) Liquid level recording gauges in overflow channels of sewage treatment plants and wet wells of lift stations to indicate when overflow takes place. Charts should be dated and initialed by the operator. Gauges should be calibrated so that discharge can be estimated.

(c) Automatic devices to warn of failure or malfunctioning at self-operated pumping stations or treatment plants.

(4) The effect of storm sewage can be calculated by multiplying the total estimated flow by the observed coliform content. The result can be expressed in terms of population equivalents (coliform).

Design and operation of equipment should be such that closure provisions should not have to be invoked more than once per year under ordinary circumstances.

A closed safety area should be interposed between the conditionally approved area and the source of pollution. The size of such area should be based on the total time it would take for the operating agency to detect a failure, notify the State shellfish control agency, and for the latter agency to stop shellfish harvesting. It is recommended that the area be of such size that the flow time through the safety area be at least twice that required for the notification process to become effective. Due consideration should be given to the possibility that closure actions might be necessary on holidays or at night.

The type of marking which will be required for conditionally approved areas will vary from State to State depending upon the legal requirements for closing an area.

The length of time a conditionally approved area should be closed following a temporary closure will depend upon several factors including the species of shellfish, water temperature, purification rates, presence of silt or other chemicals that might interfere with the physiological activity of the shellfish, and the degree of pollution of the area. (See section D-1 of this manual for additional information on the natural purification of shellfish.)

5. Restricted Areas. An area may be classified as restricted when a sanitary survey indicates a limited degree of pollution which would make it unsafe to harvest the shellfish for direct marketing. Alternatively the States may classify such areas as prohibited (see section C-6, this manual). Shellfish from such areas may be marketed after purifying or relaying as provided for in section D.

Satisfactory compliance. This item will be satisfied when the water quality criteria in

items "a" and "b" under heading, "Satisfactory Compliance" of "Approved Areas" are met in areas designated by States as restricted,[13, 14] and when shellfish from restricted areas are not marketed without controlled purification or relaying.

Public-health explanation. In many instances it is difficult to draw a clear line of demarcation between polluted and non-polluted areas. In such instances the State may, at its option, classify areas of intermediate sanitary quality as restricted and authorize the use of the shellfish for relaying, or controlled purification.

6. Prohibited Areas. An area shall be classified prohibited if the sanitary survey indicates that dangerous number of pathogenic micro-organisms might reach an area. The taking of shellfish from such areas for direct marketing shall be prohibited. Relaying or other salvage operations shall be carefully supervised to insure against polluted shellfish entering trade channels. Coastal areas which have not been subjected to sanitary surveys shall be automatically classified as prohibited.

Satisfactory compliance. This item will be satisfied when:

a. An area is classified as prohibited if a sanitary survey indicates either of the following degrees of pollution:

(1) The area is so contaminated with radionuclides or industrial wastes that consumption of the shellfish might be hazardous and/or

(2) The median coliform MPN of the water exceeds 700 per 100 ml. or more than 10 percent of the samples have a coliform MPN in excess of 2,300 per 100 ml.

b. No market shellfish are taken from prohibited areas except by special permit as described in section D.

c. Coastal areas in which sanitary surveys have not been made shall be automatically classified as prohibited.

Public-health explanation. The positive relationship between enteric disease and the eating of raw or partially cooked shellfish has been outlined in section C-1. Prevention of the interstate transport of shellfish containing sufficient numbers of pathogenic micro-organisms to cause disease is a primary objective of the Cooperative Program. Therefore, areas containing dangerous concentrations of micro-organisms of fecal origin, or which is even slightly contaminated with fresh fecal discharges, should not be approved as a source of shellfish for direct marketing.

7. Closure of Areas Due to Shellfish Toxins. The State shellfish control agency shall regularly collect and assay representative samples of shellfish from growing areas where shellfish toxin is likely to occur. If the toxin content reaches 80 micrograms per 100 grams of the edible portions of raw shellfish meat, the area shall be closed to the taking of the species of shellfish in which the toxin has been found.[15] The harvesting of shellfish from such areas shall be controlled in accord with the recommendations of sections E-1 and E-2 of this manual.

The quarantine shall remain in effect until such time as the State shellfish control agency is convinced the toxin content of the shellfish involved is below the quarantine level.[16]

Satisfactory compliance. This item will be satisfied when:

a. The State shellfish control agency collects and assays representative samples of shellfish for the presence of shellfish toxins from each suspected growing area during the harvesting season.

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13. It is not mandatory that States use this classification. Areas not meeting the approved classification may be closed to all harvesting for direct marketing.

14. Routine sanitary surveys and reappraisals of restricted areas shall be made on the same frequency as for approved areas. (See section C-1.)

15. This value is based on the results of epidemiological investigations of outbreaks of shellfish toxin in Canada in 1954 and 1957.

16. The provisions of this item apply only to shellfish which will be marketed as a fresh or frozen product as properly controlled heat processing will reduce the toxin content of the shellfish.

b. A quarantine is imposed against the taking of shellfish when the toxicity reaches 80 micrograms per 100 grams of the edible portion of raw shellfish.

Public-health explanation. In some areas, paralytic poison is collected temporarily by bivalve shellfish from free-swimming, one-celled marine plants on which these shellfish feed. The plants flourish seasonally when water conditions are favorable.

The minimum quantity of toxin which will cause intoxication in a susceptible person is not known. Epidemiological investigations of paralytic shellfish poisoning in Canada have indicated 200 to 600 micrograms of poison will produce symptoms in susceptible persons and a death has been attributed to the ingestion of a probable 480 micrograms of toxin. Investigations indicate that lesser amounts of the toxin have no deleterious effects on humans. Growing areas should be closed at a lower toxicity level to provide an adequate margin of safety since in many instances toxicity levels will change rapidly. It has also been shown that the heat treatment afforded in ordinary canning processes reduces the toxin content of raw shellfish considerably.

Section D

Preparation of Shellfish for Marketing

1. Relaying. State shellfish control agencies may approve the intra or interstate transplanting of market shellfish from restricted or prohibited areas to approved areas subject to certain limitations. All phases of the operation shall be under the immediate supervision of responsible State shellfish control or patrol agency. A memorandum of understanding shall be developed between the agencies responsible for the control of interstate relaying operations. Shellfish may be transplanted from an approved area to another like area at any time without restriction due to sanitary reasons.

Satisfactory compliance. This item will be satisfied when:

a. Shellfish are not relaid from restricted or prohibited areas to approved areas without written permission of the State shellfish control agency.

b. All relaying operations are under the immediate supervision of the State shellfish control or patrol agency. Supervision shall be such that no polluted shellfish is marketed before the end of the approved relaying period. The supervising officer shall be authorized and equipped to enforce the State regulations on relaying; shall actually supervise the harvesting, transport, and relaying of shellfish; and shall patrol the approved area during the period that shellfish are undergoing the cleansing process. However, continuous direct supervision will not be necessary if relaying operations be carried out during a period when shellfish may not be marketed. A continuous record of water temperature, salinity, and any other critical variables must be maintained when it is known that the limiting values may be approached and when the minimum relaying periods are being used.

c. State permission to relay shellfish is given only to responsible persons; responsibility to be determined by the past record of the permit applicant.

d. Relaid shellfish are held in the approved area for a period of time sufficient to allow them to cleanse themselves of polluting bacteria. (The time required for purification will be determined by water temperature, salinity, initial bacteriological quality and species of shellfish.)

e. Relaid shellfish are not harvested without written permission from the State shellfish control agency.

f. Areas designated for relaid shellfish are so located and marked that they may be readily identified by the harvesters and so that shellfish in any adjacent approved area will not be contaminated. (This requirement applies only to relaying during the harvesting season.)

g. Shellfish are not relayed intra or interstate from restricted or prohibited areas to approved areas without written permission of the State shellfish control agency. (If shellfish be relayed interstate, a memorandum of agreement shall be developed outlining the control measures to be used.)

Public-health explanation. Shellfish transplanted from a polluted to a clean environment will cleanse themselves of the polluting bacteria. This is a natural phenomenon resulting from the shellfish feeding processes. Bacteria in the body and shell cavity of the shellfish at the time of transplanting are either used as food or are ejected in feces or pseudofeces.

The length of time required for this cleansing process is influenced by many factors including original level of pollution, water temperature, presence of chemicals inhibitory to physiological activity of the shellfish, salinity, and varying capabilities of the individual animals. Advice on limiting water temperatures, either maximum or minimum, should be obtained from local marine biologists.

Investigations by marine biologists have confirmed that the physiological activities of the Eastern oyster (Crassostrea virginica) are reduced when the water temperature falls below a certain value. It has been found that the pumping rate of Eastern oysters is reduced at water temperatures below 50°F., and that most animals stop pumping at a water temperature of about 41°F. However, a few oysters show slight activity at temperatures approaching 32°F. This phenomenon was first noted by shellfish bacteriologists who found that Eastern oysters harvested from polluted areas during cold weather had coliform contents comparable with those of oysters harvested from clean areas during warmer weather.

Relaying operations must be carefully supervised by an official State agency since the shellfish may contain pathogenic micro-organisms. Control must apply to all phases of the operation including initial harvesting, transportation, replanting, purification period, and final harvesting for marketing if the relaying area be adjacent to a restricted area or to an area containing relaid shellfish which have not been released for harvesting.

2. Controlled Purification. Shellfish from restricted or prohibited areas may be marketed after effective controlled purification. Purification shall be permitted only under the immediate supervision of the State shellfish control agency. Water used for purification shall be of high bacteriological quality and its physical and chemical properties shall be favorable to maximum physiological activity of the shellfish. Stringent precautions shall be taken by the State shellfish control agency to insure that shellfish harvested from restricted or prohibited areas are actually submitted to an effective purification process before marketing.

Purification of shellfish from prohibited areas shall not be approved by the State unless relaying be not practical for biological reasons, and no public-health hazard will result from the use of such shellfish.

Satisfactory compliance. This item will be satisfied when:

a. The controlled purification system, including water treatment, has been demonstrated to be consistently effective for the species of shellfish being purified. Purification may be accomplished in either a natural body of water or in tanks. (In determining the effectiveness of the process, at least the following factors shall be investigated: Water temperature, silt or turbidity, dissolved oxygen, presence of chemicals, and time required for purification.) The bacteriological quality of the purified shellfish shall be at least equal to shellfish of the same species harvested from local approved areas.

b. A purificaion plant operating procedure is developed and copies are supplied to the Public Health Service.

c. Water used for purification is obtained from an area meeting the physical and bacteriological requirements of an approved growing area, or, in the case of treated water, the bacteriological limits of the Public Health Service Drinking Water Standards are met. If water is to be treated, it shall be obtained from an area meeting at least the sanitary requirements for a restricted area.

d. Water used for purification has chemical and physical characteristics conducive to maximum physiological activity of the shellfish. (Consideration shall be given to the following: Presence of chemicals, turbidity, temperature, salinity and dissolved oxygen, and to the adequacy of the facilities of the operating agency for measuring these characteristics.)

e. Shellfish are freed of contamination and foreign material adhering to shells before purification.

f. Shellfish are culled before and after purification.

g. Purification plant operation is under the administrative control of the State shellfish control agency. Purification plants may be operated by agencies other than the State; however, insofar as the Cooperative Program is concerned, the State is responsible for satisfactory operation.

h. Laboratory control is maintained over the purification operation. Controls shall include at least the following: Daily or tidal-cycle bacteriological quality of water; final bacteriological quality for each lot of shellfish purified; and, when they are critical factors, hourly or continuous salinity determinations and tidal-cycle turbidity determinations.

i. The plant operator possesses a satisfactory knowledge of the principles of water treatment and bacteriology.

j. Animals, rodents, and unauthorized persons are excluded from the plant.

k. Plant employees fulfill the qualifications for a shucker as described in section B-28, part II of this manual.

l. The State has an effective system for assuring that shellfish harvested from restricted areas will be submitted to purification before marketing. Shellfish harvesting from prohibited areas for controlled purification shall be under the immediate supervision of the State.

m. Shellfish from prohibited areas are not subjected to purification unless the State shellfish control agency can show that relaying or depletion is not biologically feasible; and that no public-health hazard will result from the use of such shellfish.

Public-health explanation. The ability of shellfish to purify themselves in clean water was discovered early in the 1900's. The biological process is reasonably well understood and was described by Arcisz and Kelly in 1955 as follows:

"Purification is a mechanical process effected by the physiological functioning of the shellfish in clean water. When shellfish are feeding, the gills act as a filter to strain out some of the material that may be brought in by the water which passes through them. If this water contains sewage, some of the micro-organisms in it are entrapped in the mucus on the body of the shellfish and transferred to the alimentary tract. Some of these are perhaps utilized as food and the others discharged from the body in the form of feces and pseudofeces. When shellfish from polluted water are placed in clean water, the sewage bacteria are eliminated from the shellfish, and, since no more are ingested, purification is accomplished."

The technique of the purification process is reliable if proper methods be used, and insofar as is known, is applicable to all commercial species of shellfish.

Many of the earlier investigators suggested that purification be accomplished in tanks using water which had been subjected to a treatment process. The analogy with water treatment was carried to the point of recommending a chlorine residual in the purification tanks. However, fishery biologists have shown that shellfish pumping is decreased or inhibited by even small quantities of chlorine. The inhibitory effect of chlorinated-dechlorinated water on activity of Eastern oysters has been noted by the Public Health Service Shellfish Sanitation Laboratory.

Since purification depends upon the pumping rate of the shellfish, it is important that the water be free of chemicals or physical characteristics which might interfere with this activity. For example, silt or dissolved organic substances may influence the pumping rates of shellfish. The relationship of water temperature to pumping rates has been mentioned previously.

Shellfish purification facilities have generally been considered to include holding tanks and water treatment facilities; however, investigations in Canada and England have demonstrated that purification can be accomplished with relatively simple installations if the operation be supervised properly. Accordingly, any purification process of proven effectiveness will be accepted by the Cooperative Program.

Administrative control of the purification process is necessary to insure that shellfish be properly washed and culled, be held for the required length of time, and that the purification water supply be properly controlled.

Section E

Control of Harvesting From Closed Areas

1. Identification of Closed Areas. Shellfish harvesters shall be notified by direct notice and warning signs of areas closed to harvesting. Closed areas shall be so marked or described

that they may be easily recognized by the harvesters. The measures necessary to accomplish delineation and notification will vary with the structure of the local shellfish industry and with the legal requirements of each State.

Satisfactory compliance. This item will be satisfied when:

a. The boundaries of the closed areas are marked by fixed objects or landmarks in a manner which permits successful prosecution of any violations of the closed areas.

b. Shellfish harvesters are notified of the location of closed areas by publication or direct notification (such as registered mail) and by warning signs posted at points of access to each closed area. The method of notification and identification should permit the successful prosecution of persons harvesting shellfish from the closed areas. (The limiting of shellfish harvesting permits to specific areas is an alternative to posting or notification. Where such a system is used, posting will be required only for closed areas which contain market shellfish.)

Public-health explanation. Previous sections of this manual have described the public-health reasons for limiting shellfish harvesting to areas free of contamination and paralytic shellfish toxin. Methods have been described for the evaluation and classification of such areas. However, classification is not effective unless the State can prevent illegal harvesting of shellfish for direct marketing from these closed areas.

For the most part, control of illegal harvesting depends upon the police activities as described in section E-2. However, adequate delineation of the closed areas is fundamental to effective patrol.

The type of area identification will be determined by the structure of the local shellfish industry. Posting a warning sign is one method of informing shellfish harvesters that an area is closed to the taking of shellfish for public-health reasons. However, if the local shellfish industry be highly organized, with shellfish being harvested by only a few operators, identification may be accomplished by officially informing the harvesters that certain areas are closed to the taking of shellfish. It is recommended that the advice of the State's legal counsel be obtained to insure that the marking of closed areas and notifications to shellfish harvesters are such that illegal harvesting can be prosecuted successfully.

2. Prevention of Illegal Harvesting of Shellfish From Closed Areas. Closed growing areas shall be patrolled by a State agency to prevent illegal harvesting. The patrol force shall be so equipped that its officers will be able to apprehend persons taking shellfish from closed areas.

Satisfactory compliance. This item will be satisfied when:

a. There is no evidence that shellfish are being harvested from closed areas except by special permit as required to meet local conditions.

b. Closed shellfish growing areas are patrolled by representatives of an official agency, due consideration being given to night, week-end and holiday patrols. (States may delegate patrol activities to local organizations; however, responsibility for effective control will remain with the State insofar as the Cooperative Program is concerned.

c. Patrol forces are so equipped that persons observed in closed areas may be apprehended.

d. Complete records of patrol activities, including violations and court actions, are maintained in the central office of the State shellfish control or patrol agency. It will be the responsibility of the State to include local patrol activities in these records. (See section A, subsection 2 (e) regarding monthly summaries of patrol activities.)

Public-health explanation. The primary objective of the Cooperative Program is to insure that shellfish will be harvested only from areas which are free of dangerous concentrations of pathogenic micro-organisms, industrial or radioactive wastes, or paralytic shellfish toxin.

Growing areas may be classified as to their public health suitability for shellfish harvesting on the basis of information obtained by sanitary and toxicological surveys. However, if local shellfish harvesters be not convinced of the need for restrictions, shellfish may be harvested surreptitiously from the closed areas. Thus, patrol failure may nullify the public health safeguards resulting from sanitary survey activities.

The fact that law prohibits the removal of shellfish from certain areas will deter most persons from attempting to harvest such shellfish provided they are aware of the law and of the areas which are closed. However, local public opinion may not support the need for such closures. In such cases favorable opinion can probably be developed only through an educational program or a locally demonstrated need such as an epidemic or outbreak of paralytic shellfish poisoning. There is also a minority element not concerned with the welfare of their customers and who, through ignorance or purpose, will attempt to circumvent the harvesting restrictions.

Patrols must, therefore, be directed against three classes of individuals; i.e., those who are ignorant of the law, those who believe the law is unjust or unreasonable, and those who have no regard for the law.

Several mechanisms for improving the effectiveness of patrols include educational programs to acquaint shellfish harvesters with the public health reasons for the closures, elimination of the "temptation element" by depletion, and relaying or purification. Apprehension, prosecution, and punishment of violators is a final resort.

The type of patrol organization needed for any particular situation cannot be specified and is determined by the nature of areas to be patrolled, means of access, methods of harvesting, and species. Patrol equipment should be such that the officers can apprehend persons harvesting shellfish in a closed area. Necessary equipment might include patrol boats capable of operating in open waters; small high-speed, readily transportable boats, or patrol automobiles. In many instances, two-way radio will be helpful in coordinating patrol activities.

Organization of the patrol activity must take into consideration the need for night, weekend, holiday, and surprise patrols. Either nuisance or continual patrol may be used depending on the nature of the area to be patrolled and the type of industry.

The adequacy of state laws as a basis for prosecution is an important component of this activity. Shellfish patrol will probably be ineffective if State laws be so written or interpreted that violators cannot be successfully prosecuted, or if penalties be so small that they are economically unimportant. The latter point may be important in an area where local public opinion does not support the need for the restriction.

3. Depletion of Closed Areas. The State shellfish control or patrol agency shall supervise all depletion operations. All market-size shellfish and as many of the smaller size as can be gathered by reasonable methods shall be removed in the initial depletion operation. Depletion of each area shall be carried out at intervals to prevent the development of market-sized shellfish.

Satisfactory compliance. This item will be satisfied when:

a. The State shellfish control or patrol agency exercises direct supervision over each depletion project including patrol of the area in which shellfish are relaid. (See section D-1.)

b. All market shellfish and as many of the smaller size shellfish as can be gathered by reasonable methods are removed in the depletion operation.

c. Similarly supervised depletion operations are carried out at intervals to prevent development of market-sized shellfish in quantities which would make commercial harvesting economically practicable in the depleted areas.

Public-health explanation. Complete removal of shellfish from polluted to clean areas under appropriate precautions is the best safeguard against contaminated shellfish reaching the market. In some cases depletion may be more economical and effective than patrol of closed areas.

Appendix A

Bacteriological Criteria of Shellfish and Shellfish Waters

The bacteriological examination of shellfish and shellfish growing waters is important in evaluating the sanitary quality of the aquatic environment, the sanitary quality of the shellfish as harvested, and, the changes in the sanitary quality of shellfish which occur during harvesting, shucking-packing, and marketing.

Section C of this manual outlines the procedures to be followed in evaluating the sanitary quality of an area. The objective data obtained through bacteriological examination of water samples is frequently indispensable in making such evaluations. However, the statistical and biological factors which influence bacteriological results must be recognized and understood if valid interpretation of results be obtained. The purpose of this appendix is to describe some of these factors as they were understood in 1958, the date of drafting this material, and to mention some additional sources of information.

Shellfish will generally reflect the bacteriological quality of the water in which they have grown. However, this relationship is apparently not sufficiently constant to permit development of a uniform bacteriological standard which could be applied to all species of shellfish. For example, the soft shell clam (Mya arenaria) shows a consistently higher coliform content than do other species harvested from areas of like sanitary quality. Similarly, Eastern oysters harvested from South Atlantic and Gulf areas have a higher coliform content than those from the Middle Atlantic States.[17] Seasonal variation is also pronounced.

The bacteriological quality of Eastern oysters harvested from the North and Middle Atlantic regions has been well investigated. Oysters as harvested from approved areas in these two regions should not ordinarily exceed a coliform MPN of 230 per 100 grams of shellfish meats although a few samples may approach or exceed 2,400 per 100 grams. If this latter value be exceeded in two consecutive samples, the State shellfish control agency should investigate to determine the probable cause.

Eastern oysters harvested from Chesapeake Bay, South Atlantic or Gulf States cannot be expected to meet routinely this standard of 230 per 100 grams even though harvested from water of like sanitary quality.

Oysters as harvested from Gulf areas might ordinarily have a coliform MPN of less than 2,400/100 grams. However, if this value be exceeded in two consecutive samples, the State shellfish control agency should undertake an investigation to determine the probable cause.

The bacteriological quality of hard clams (Mercenaria mercenaria) harvested from the New England and Middle Atlantic States has also been thoroughly investigated and the relationship seems well established. The findings of many State investigations are supported by Public Health Service Shellfish Sanitation Laboratory findings which indicate the limiting coliform MPN's described for Eastern oysters from the New England and Middle Atlantic States and which are also applicable to hard clams harvested from similar areas. It is not known if similar bacterial results could be expected in hard clams harvested from Chesapeake Bay or South Atlantic States.

The bacteriology of soft shell clams (Mya arenaria) has also been investigated extensively in the Canadian Maritime Provinces and the New England and Middle Atlantic States. Data indicate that the limit of 230 cannot always be met in the case of soft clams harvested from approved areas and also that they will consistently have higher coliform MPN's than oysters or hard clams harvested from the same area. Preliminary investigations indicate high coliform found in soft clams harvested from the relatively warm water of Chesapeake Bay although the water quality be high and the areas free of pollution. If a coliform MPN of 2,400/100 grams of soft-clam meats be exceeded in two successive samples of clams as harvested from approved areas, the State shellfish control agency should investigate to determine the probable cause.

Studies on the bacteriological quality of mussels harvested from approved areas in the Canadian Maritime Provinces, New England, and the Middle Atlantic States indicate that the water to shellfish coliform relationships are similar to those described for soft shell clams. However, mussels may have somewhat higher MPN than other shellfish species harvested from like areas.

It is emphasized that the foregoing bacteriological relationships apply only to shellfish at the time of removal from the growing areas and not to shell stock in storage for any appreciable period of time, or to shucked shellfish.

The influence of shucking, packing, and storage on the bacteriological quality of the shucked product has been recognized for years. Kelly in 1942 had reported a positive correlation be-

17. The geographic subdivisions used coincide with those used in "Fishery Statistics of the United States," Fish and Wildlife Service, U. S. Department of the Interior.

tween plant sanitation or operating practices and the standard plate count of the product.

The Canadian Department of National Health and Welfare in 1950 pointed out that most of the United States shucked Eastern oysters sold in Canada had high coliform MPN's, high standard plate counts, or both. They reported that of 77 shipments of shucked Eastern oysters from the United States, 44.2 percent had a coliform MPN of less than 230 while 41.5 percent had coliform MPN's in excess of 16,000 per 100 grams. These results, when interpreted in accord with the 1946 manual of Recommended Practice for Sanitary Control of the Shellfish Industry indicated the oysters were from a polluted source or had been grossly mishandled.

The significance of these results was discussed at the 1950 meeting of the Canadian Interdepartmental Shellfish Committee. On the basis of limited information on the sanitary quality of similar shellfish sold on the American markets, it was decided to establish an interim bacteriological standard for shucked Eastern oysters sold in Canada. This standard was based on the premise that an increase in the bacteria content of market shellfish was unavoidable. Adoption of this interim standard by Canada resulted in a significant improvement in the sanitary quality of shucked oysters imported from the United States.

In 1950 the Public Health Service, in cooperation with the Government of Canada and several State health departments, investigated the bacteriological changes occurring during the processing and shipment of oysters from Chesapeake Bay to selected market areas. The study demonstrated a marked deterioration in bacteriological quality during shucking and shipment to market.

In 1954 and 1955 the Virginia Department of Health found that during shucking and packing in the winter months about two-thirds of the shell oysters had coliform MPN's of 230 or less per 100 grams. However, during the summer months few samples were under 230/100 grams and only 25 percent were below 2,400. On the "as packed" product during the winter months, 10 percent of the samples had a coliform MPN of 230 or less, 50 percent were 2,400 or less, 75 percent were 9,000 or less, and 90 percent were below 24,000.

The bacterial changes taking place during the harvesting and processing of oysters in the Gulf States has been investigated by the Public Health Service Shellfish Sanitation Laboratory in cooperation with the States. These studies have shown: (1) oysters as harvested in the Gulf States are of higher coliform content than are those harvested from areas of like sanitary quality in New England and Middle Atlantic States; (2) a significant increase in the coliform content may take place in the shell oyster prior to shucking; and (3) an increase in bacteria content takes place during schucking.

Results obtained in these bacteriological studies of shellfish harvesting, shucking-packing and marketing were reviewed at the 1956 Shellfish Sanitation Workshop. In recognition of the data presented, the 1956 Workshop recommended the temporary use of an "Acceptable," "Acceptable-on-Condition," and "Rejectable" classification based on a combined coliform MPN--standard plate count index of quality for shucked Eastern oysters as marketed. The 1956 Workshop also recommended that the Public Health Service and the interested States undertake a cooperative study of the bacteriological quality of shucked Eastern oysters shipped from Chesapeake Bay to New York and Canadian markets. Such a cooperative study was undertaken by the interested State and Federal agencies in the fall of 1956.

The results of this two-year study were discussed at the 1958 Shellfish Sanitation Workshop. On the basis of these discussions the Workshop recommended a two part "Acceptable-Rejectable" interim market standard for shucked Eastern oysters based on fecal coliform MPN's and standard plate counts.

Part II

Section A

Harvesting and Handling Shell Stock

1. Boats and Trucks. All boats used in tonging, dredging, or transporting shellfish, including "buy" boats, and all trucks used for hauling bulk shell stock shall be so constructed, operated, and maintained as to prevent contamination or deterioration of the shellfish, and shall be kept clean.

Public Health reason. Precautions exercised in gathering shellfish from approved growing areas may be nullified by contamination with bilge water or polluted overboard water.

Satisfactory compliance. This item will be satisfied when:

a. Decks and/or storage bins are so constructed and located as to prevent bilge water

or polluted overboard water from coming into contact with the shellfish. Removable false bottoms will ordinarily be required in all small craft, including rowboats, skiffs, and power boats, used in the transport of shell stock.

b. Bilge pumps are so located that pumpage will not contaminate shellfish.

c. Sacks or other containers used for the storage of shellfish are clean.

d. Boat decks and storage bins are kept clean with water from an approved source.

e. That portion of boats or trucks (decks, storage bins, floor beds, etc.) and all other equipment (shovels, wheelbarrows, rakes, etc.) in contact with shell stock during handling or transport from polluted areas to approved areas for relaying are thoroughly cleaned before they are used for the transport or handling of shellfish from approved areas.

f. Trucks used for the transport of bulk shell stock are so constructed as to protect the shellfish from contamination, and are kept clean.

2. Washing of Shell Stock. Shell stock should be washed reasonably free of bottom sediments and detritus as soon after harvesting as is practicable. The primary responsibility for washing rests with the harvester. Water used for shell-stock washing should be obtained from an approved growing area, or from other sources approved by the State regulatory agency.

Public-health reason. When muddy shell stock are shucked, quantities of mud and bacteria are mixed with the shucked shellfish, thereby contributing to high bacteria counts in the finished product.

The Public Health Service's Shellfish Sanitation Laboratory found that during shucking, the percentage of samples of oysters having coliform Most Probable Numbers (MPN's) in excess of 2,400 per 100 ml. of meats was found to increase from 18 to 72, and the percentage of samples of oysters having coliform MPN's in excess of 24,000 per 100 ml. of meat increased from zero to 14. Mud and detritus adhering to the shells were implicated as responsible for the increase in coliform counts.

Muddy shell stock make it difficult to maintain shucking rooms in a clean, sanitary condition. Water used for shell-stock washing should be of good sanitary quality, to avoid possible contamination of the shell stock.

Satisfactory compliance. This item will be satisfied when:

a. Shell stock are washed reasonably free of bottom sediments and detritus as soon after harvesting as is feasible. Washing of naturally clean shell stock is not necessary. Shell stock should preferably be washed at the time of harvesting; however, this may not always be feasible because of the harvesting method or climatic conditions. In other instances, shell-stock washing by the harvester might introduce a sanitary hazard because of the possible tendency of the harvester to wash the shell stock with polluted water from a harbor area rather than with clean water from a growing area. State shellfish control authorities may, therefore, at their discretion, waive the requirement for shell-stock washing by the harvester when, in the State's opinion, there are climatic, technical, or sanitary reasons for such action.

b. Water used for washing shell stock is obtained from an approved growing area, or from other sources approved by the State regulatory authority.

3. Disposal of Body Excretions. During the marketing season, body excretions shall not be discharged overboard from a boat used in harvesting shellfish, or from "buy" boats while in areas from which shellfish are being harvested. The State Shellfish control agency, when necessary, shall specify the device and practice necessary to eliminate the overboard discharge of body excretions from boats used in harvesting of shellfish.

It is recommended that each State shellfish control agency maintain an educational program for boat owners concerning the public health significance and dangers inherent in the overboard discharge of body waste.

Public-health reason. Gastrointestinal infections may be conveyed by shellfish; hence, it is necessary to protect the shellfish from pollution by disease causing organisms that may be present in body excretions. This item is intended to protect the shellfish from chance pollution during harvesting. The discharging of body excretions from either harvesting or "buy" boats will be considered in the evaluation of harvesting practices.

Satisfactory compliance. This will be satisfied when:

a. No body excretions are discharged overboard from a boat used in harvesting shellfish while in an area from which shellfish are being harvested.

b. No body excretions are discharged from a "buy" boat while in an area in which shellfish are being harvested.

c. It is evident that soil cans, if provided, are used for the purpose intended.

d. Soil cans, where used, are so secured and located as to prevent contamination of the shellfish by spillage or leakage.

e. The contents of soil cans are disposed of by discharge into an approved sewage disposal system, and soil cans are cleaned before being returned to the boat.[18] (Facilities used for cleaning food-processing equipment may not be used for this purpose.)

4. Licenses for Commercial Harvesters. Each person who handles unshucked shellfish prior to delivery or sale to a dealer certified under the Cooperative Program shall have a valid State permit or license to do so.

In the case of leased land, either the lessee shall be licensed or the person which harvests shall be licensed by the State. The State agency having primary responsibility for granting licenses shall maintain a record of all such licenses granted for review by the appropriate Public Health Service Regional Office.

Satisfactory compliance. This item will be satisfied when:

a. Each person harvesting shellfish has a valid permit or license to do so.

b. The State agency having responsibility for granting licenses maintains a record of all such licenses granted for review by the appropriate Public Health Service Regional Office.

c. In the case of leased growing area(s), either the lessee or the person who harvests shall be licensed by the State.

Section B

Shucking and Packing Shellfish

1. Wet Storage. Shellfish in wet storage shall be protected against sewage contamination. Wet storage shall not be practiced by a shipper unless written approval be given each year by the State regulatory authority. This approval is to include a sketch, drawn to scale, showing the approved location of the storage area, floats or the water intake for the wet-storage tanks, and all the potential hazards to which the stored shellfish may be exposed. The approval statement shall describe the measures taken to protect the shellfish from the potential hazards. The presence of usable wet-storage tanks in a plant, or the presence of usable floats in the water, shall be deemed evidence that wet storage is being practiced.

Public-health reason. Removal of shellfish from growing beds to storage areas close to shore and habitations, and frequently in shallow water, may subject an accumulated quantity of shellfish to constant or intermittent pollution. Shellfish in wet-storage tanks are similarly subject to pollution if the water be obtained from a polluted source. Shellfish on floats are more directly exposed to chance contamination from boats than are shellfish stored in the growing areas themselves, since it is customary to "float" the shellfish near the surface, where fresh sewage is apt to be found in greatest concentration. Shellfish on floats, therefore, are protected to a less degree by dilution than are shellfish on bottom areas.

Satisfactory compliance. This item will be satisfied when:

a. Shellfish in wet storage are protected against sewage contamination.

b. Wet storage is practiced only in strict compliance with the terms of the written approval of the State regulatory authority. This approval is to include: (1) a sketch, drawn to scale, showing the location of the storage area or water intakes and the potential hazards to which the shellfish may be exposed; and (2) a statement describing the measures taken to protect the shellfish from the above potential hazards. This written approval shall be valid for not more than 12 months.

18. For use and construction of soil-can-washing facilities, see Public Health Service Publication No. 66, Handbook on Sanitation of Railroad Servicing Areas.

2. Plant Arrangement. Plants in which shellfish are shucked and packed shall, to the extent feasible, be so located that they will not be subject to flooding by high tides. If plant floors become flooded, shucking shall be discontinued until after waters have receded and the building cleaned.

Shucking and packing operations shall be conducted in separate rooms. A shucked-stock delivery window shall be installed in the partition between the two rooms. Packing rooms shall be of sufficient size to permit sanitary handling of the product and thorough cleaning of equipment.

A separate room or rooms, or lockers, shall be provided for storing employees' street clothing, aprons, gloves, and personal articles.

Public-health reason. The nature of the shucking operation is such that the shuckers' clothing becomes very soiled. If shuckers enter the packing room, shucked stock, cans, and other equipment may become contaminated. Rooms or lockers should be provided for clothing, aprons, and gloves to eliminate the tendency to store such articles on the shucking benches or in packing rooms, where they interfere with plant cleanup and operation.

Satisfactory compliance. This item will be satisfied when:

a. Processing establishments are so located that they will not be subject to flooding by ordinary high tides. (A minimum plant elevation of at least 2 feet above high tides is recommended.) If plant floors be flooded, shucking is discontinued until after waters have receded and the building is cleaned.

b. Shucking and packing operations are carried on in separate rooms. Flytight screening may be accepted in lieu of a solid wall between the shucking and packing rooms, provided that the packing room is so situated that there be no likelihood of the shucked product or packing-room equipment being contaminated by splash from the opening between the rooms.

c. The delivery window is equipped with a corrosion-resistant shelf of metal, concrete, or tile, draining toward the shucking room and, if necessary, curbed on the packing-room side.

d. Packing rooms are large enough to permit sanitary handling of shellfish and thorough cleaning of equipment.

e. Rooms or lockers are provided which have adequate capacity for storing clothing, aprons, gloves, and other personal articles of employees.

3. Dry Storage of Shell Stock. Shell stock in dry storage shall be protected from contamination. Rooms, benches, or hoppers shall be provided for the storage of shell stock. Floor wastes from a shell-stock storage area shall be discharged through a separate drainage system, or, if discharged into a general drainage system carrying sanitary wastes, an air gap shall be provided.

Public-health reason. If shell stock be stored where polluted ground or surface water or floor drainage can accumulate, the shell stock may become contaminated. Shell stock may also be contaminated by domestic animals and rodents (see Section B, Items 12 and 15).

Satisfactory compliance. This item will be satisfied when:

a. The storage area floor is constructed of material impervious to water, is free from cracks and uneven surfaces that interfere with proper cleaning or drainage, and is graded to assure complete and rapid drainage of water away from the shellfish.

b. Walls of shell-stock storage rooms and hoppers are smooth and of material which will not deteriorate under repeated washing.

c. Shell-stock storage areas are so constructed that they will not receive floor drainage water from other portions of the plant. If such construction be not feasible, the shell stock should be stored on racks to prevent them from coming into contact with the floor or with water which might accumulate on the floor. Shell-stock storage areas should not serve as an entry way to other areas of the establishment. Shell-stock storage areas are protected against sewage backflow by the installation of an airgap in the waste line or by provision of a separate drain system.

d. Conveyances or devices used in the transport of shell stock are so constructed that they may be easily cleaned and are kept reasonably clean. (Use of impervious material is

recommended wherever possible.)

4. Floors. Floors shall be constructed of concrete or other material impervious to water, and shall be graded to drain quickly, shall be free from cracks and uneven surfaces that interfere with proper cleaning or drainage, and shall be maintained in good condition.

Satisfactory compliance. This item will be satisfied when:

a. The floors of all rooms in which shellfish are shucked or packed, or in which utensils are washed, are constructed of concrete of good quality, or of equally impervious tile laid closely with impervious joint material, or of metal surfacing with impervious joints, or of any other material which is equivalent to good quality concrete; and when the floors are maintained in good repair.

b. The floor surface is smooth, and graded to drain, and the junctions between floors and walls are impervious to water.

5. Walls and Ceilings. The interior surfaces of rooms in which shellfish are shucked or packed, or in which utensils are washed, shall be smooth, washable, light-colored, and kept in good repair.

Satisfactory compliance. This item will be satisfied when interior surfaces are of tile, concrete, cement plaster, concrete blocks, painted wood, or equivalent material, having a smooth, washable, light-colored surface. (Structural members may be exposed, provided that they do not interfere with cleaning.)

6. Fly-Control Measures. All outer openings to toilet and wash rooms, shucking and packing rooms, utensil cleaning and storage rooms, and locker rooms shall be effectively screened during the seasons when flies are present, unless other effective means be provided for preventing the entrance of flies. Effective in-plant fly-control measures shall be used to kill or capture flies which may enter the plant despite the screening. Shell-stock storage rooms shall be screened as necessary, to prevent the entrance of flies into the other portions of the plant. All interior doors or other openings into the packing room should be screened whenever necessary to keep the packing room free of flies.

Satisfactory compliance. This item will be satisfied when:

a. All outer openings are effectively screened whenever flies are present; or other effective devices are provided to prevent the entrance of flies.

b. Screen doors open outward and are self-closing.

c. Flies are not present.

d. Necessary internal fly-control measures are used, and such measures are approved by the State regulatory authority.

7. Lighting. Ample natural and/or artificial light shall be provided in all working and storage rooms.

Satisfactory compliance. This item will be satisfied when work and storage rooms are lighted to at least the intensity indicated below:

Type of Area	Foot-Candles of Illumination[a]
Working surfaces in packing rooms[b]	25
Shucking benches and utensil-washing areas[b]	15
Storage rooms, including cold-storage rooms[c]	5

a. Approximate. Measure as incident light.

b. Overall illumination level in area should be at least 10 ft. candles.

c. Measures 30 inches above the floor.

8. Heating and Ventilation. Working rooms shall be ventilated, and shall be heated when necessary.

Public-health reason. Uncomfortable working conditions impair the efficiency of the workers, and may result in insanitary practices.

Proper ventilation reduces condensation, and aids in retarding the growth of mold.

Satisfactory compliance. This item will be satisfied when:

a. A comfortable working temperature is maintained.

b. Sufficient ventilation is provided to eliminate odors, discomfort, and excessive condensation.

9. Water Supply. The water supply shall be easily accessible, adequate, and of a safe and sanitary quality.

Satisfactory compliance. This item will be satisfied when:

a. The water supply is approved as safe by the responsible State authority, or complies with the Public Health Service Drinking Water Standards. (Private water systems are so constructed and operated as to be at least equal to the recommendations contained in Public Health Service Publication No. 24, "Individual Water Supply Systems".)

b. All shell-stock storage rooms, shucking and packing rooms, and utensil washrooms are provided with water outlets.

c. An automatically regulated hot-water system is provided which has sufficient capacity to furnish water with a temperature of at least 130°F. during all hours of plant operation. (See section B, item 10e concerning requirement for mixing faucets at handwashing facilities.)

d. Sufficient water is available for all plant needs. (Nonpressure supplies will not constitute compliance.)

e. Hot and cold water outlets are provided at each sink compartment, except that warm water only may be acceptable at handwashing sinks as provided by section B, item 10e.

10. Plumbing and Related Facilities. Plumbing shall be installed in compliance with State and local plumbing ordinances, or, in the absence of such ordinances, shall be substantially equivalent to the recommendations contained in the American Standard National Plumbing Code ASA A40.8-1955. Lavatories with running hot and cold (or warm) water shall be so located that their use by plant personnel can be readily observed. Signs shall be posted in toilet rooms and near lavatories, directing employees to wash their hands before starting work and after each interruption. Conveniently located, separate toilets shall be provided for each sex; however, separate toilet facilities for each sex shall not be required when family shucking is carried on and satisfactory toilet facilities are located nearby, or when the plant has fewer than 10 employees.

Satisfactory compliance. This item will be satisfied when:

a. Plumbing is installed in compliance with State and local plumbing ordinances, or is substantially equivalent to the recommendations contained in the American Standard National Plumbing Code ASA A40.8-1955.

b. There are no cross-connections between the approved pressure water supply and water from a nonapproved source, and there are no fixtures or connections through which the approved pressure supply might be contaminated by back-siphonage.

c. There is at least 1 lavatory for every 20 employees among the first 100 employees, and at least 1 lavatory for each 25 employees in excess of the first 100. (Twenty-four lineal inches of wash sink or 18 inches of a circular basin, when provided with water outlets for such space, will be considered equivalent to 1 lavatory.)

d. Handwashing facilities are convenient to the work areas, and are so located that the person responsible for supervision can readily observe that employees wash their hands before beginning work and after each interruption. (Ordinarily, there should be at least one lavatory in the packing room for use by packing-room workers.)

e. The lavatories are provided with hot water (at least 100°F.), either from a controlled-temperature source with a maximum temperature of 115°F., or from a hot-and-cold mixing or combination valve. (Steam-water mixing or steam-water combination valves are not acceptable.)

f. Supplies of soap and single-service hand towels are available near the lavatory.

(Other sanitary drying devices, if approved by the State regulatory agency, are also acceptable.)

g. Handwashing signs are posted in toilet rooms and near lavatories.

h. The toilet-room doors are tight-fitting and self-closing.

i. The toilet rooms are kept clean and in good repair.

j. A supply of toilet paper is available in the toilet rooms.

k. At least 5-foot-candle illumination (natural or artificial) is provided in toilet rooms; and toilet rooms are ventilated by a direct opening to the outer air, or by a mechanical ventilating system. (Exhaust fans, if used, should have a minimum capacity of 2 cubic feet a minute per square foot of floor area.) Air vents should be screened or have selfclosing louvers.

Conveniently located, separate toilets are provided for each sex, excepting that separate facilities need not be required when family shucking is carried on and satisfactory toilets are located nearby, or when the plant has fewer than 10 employees. The number of water closets provided complies with applicable State laws. In the absence of such laws, the following number of water closets should be provided:

Number of employees	Number of water closets[1]	
	Male	Female
1 to 9	1	1
10 to 24	2	2
25 to 49	3	3
50 to 74	4	4
75 to 100	5[2]	5[2]

1. Wherever urinals are provided, one water closet less than the number specified may be provided for each urinal installed, except that the number of water closets in such cases should not be reduced to less than two-thirds of the minimum specified. A 24-inch trough will be considered equivalent to 1 urinal.

2. One additional fixture for every 30 employees over the first 100.

m. No drainpipes or wastepipes are located over food processing or storage areas, or over areas in which containers or utensils are stored or washed.

11. Sewage Disposal. Sewage shall be discharged into public sewers wherever possible. Where private sewage disposal systems must be utilized, they shall be constructed according to State and local requirements; provided, that privies shall be acceptable only where water-carriage systems are not feasible. All newly constructed individual water-carriage systems shall be at least equal to the recommendations contained in the "Manual of Septic Tank Practice," Public Health Service Publication No. 526. All sewage disposal facilities shall be so constructed and maintained that waste will be inaccessible to flies and rodents.

Satisfactory compliance. This item will be satisfied when:

a. Sewage is discharged into public sewers wherever possible.

b. Any private sewage-disposal facilities which are utilized are constructed and operated so as to comply with State and local requirements and privies are accepted only where water-carriage systems are not feasible. Any newly constructed individual water-carriage systems are at least equal to the recommendations contained in the "Manual of Septic Tank Practice," Public Health Service Publication No. 526.

c. No human excreta are accessible to flies or rodents.

12. Rodent Control. Shellfish processing plants shall be free from rodents.

Satisfactory compliance. This item will be satisfied when:

a. The plant is so constructed as to prevent ready entrance of rodents, and there is no evidence of rodents in any part of the plant.

b. Rodenticides which are highly toxic to humans are not stored in shellfish processing plants, and are not used except under the supervision of a licensed pest-control operator or

other qualified specialist. (Rodenticides which have a low toxicity for humans should be identified, stored, and used in such a manner as to prevent contamination of the product or ingredients, and to cause no health hazards to employees.)

13. Construction of Shucking Benches and Tables. The tops of shucking benches and tables, and contiguous walls to a height of at least 2 feet above the bench top, shall be of smooth concrete, corrosion-resistant metal, or other durable, nonabsorbent material, free from cracks, and so constructed that drainage is complete and rapid and is directed away from the stored shellfish. Shucking blocks shall be easily cleanable. Wooden shucking blocks, if used, shall be of solid, one-piece construction, and shall be easily removable. Shucking blocks of lead or other toxic materials are prohibited. Stands or stalls, if any, shall be of painted, finished material. Shuckers' stools shall have no attached padding, and are so constructed as to be easily cleaned.

Satisfactory compliance. This item will be satisfied when carried out as explained above.

14. Construction of Utensils and Equipment. The food product zone of utensils and equipment, including that used for ice handling, shall be made of smooth, corrosion-resistant, impervious, nontoxic material which will not readily disintegrate or crack; and the utensils and equipment shall be so constructed as to be easily cleaned, and shall be kept in good repair.[19]

Satisfactory compliance. This item will be satisfied when:

a. All pails, dip buckets, colanders, skimmers, paddles, tables, storage containers, returnable containers, blowers, and other equipment which come into contact with shucked shellfish, or with ice used for direct cooling of shellfish, are constructed of corrosion-resistant, nonabsorbent, nontoxic, smooth material which will not readily crack or disintegrate. (The use of enameled, tinned, or galvanized material in the food-product zone of equipment other than single-service shipping containers is not acceptable.

b. There are no exposed screw, bolt, or rivet heads in the food-product zone and all joints in the food-product zone are welded or soldered flush and have a smooth surface. (The use of welded joints which have been ground smooth is recommended, because soldered joints have been proven to be generally unsatisfactory for equipment used in the shellfish industry.)

c. Tanks, tubs, and shucked-stock storage containers are so located that their top rim is at least 2 feet above the floor.

d. All utensils and equipment are in good repair.

e. All equipment, including external and internal blower airlines and/or hoses below a point 2 inches above the overflow level of the tank, and blower drain valves, is so constructed as to be easily cleanable; when perforations in skimmers and colanders are smooth, to facilitate cleaning; when all internal angles in the food-product zone are filtered or otherwise fabricated to have an internal radius of at least 1/4-inch; and when there are no V-type threads in the food-product zone of the blower. (The use of wire mesh in the food-product zone of equipment is not acceptable. Nonfood-product zone equipment should be so constructed that they can be kept in a clean, sanitary condition; seams should be welded or filled with solder; and there should be no inaccessible spaces in which dirt or organic material might accumulate.

f. The blower drain is not directly connected with a sewer.

g. A stand or shelf, constructed of corrosion-resistant material, for the receiving containers, located at least 2 feet above the floor, is provided under all chutes from skimmers and blowers unless blowers discharge directly to a skimmer.

h. Air-pump intakes are located in a protected place.

i. Containers are clean; are fabricated of nontoxic metal, waxed paper, glass, or other impervious material; are so designed and fabricated that the contents will be protected from contamination during shipping and storage; covers of returnable containers are so designed as to protect the pouring lip of the container; and returnable containers are sealed so that tampering can be detected.

j. All blower tanks, skimmers, returnable shipping containers, shucking buckets and pans purchased and/or installed, shall comply with the Sanitation requirements contained in the Shellfish Industry Equipment Construction guides published by the Public Health Service. (Copies are available from State Shellfish sanitation agencies of Public Health Service Regional

19. For packaging containers, see section B, item 24.

Offices.)

15. General Cleanliness. Premises shall be kept clean and free of litter and rubbish. Miscellaneous and unused equipment and articles which are not necessary to plant operations shall not be stored in rooms used for shell-stock storage, shucking, packing, or repacking. No domestic animal or fowl shall be permitted to be in a shellfish-processing plant. The shell-stock storage, shucking, and packing portions of the plant, when in operation, shall be restricted to the handling of shellfish. Unauthorized persons shall be excluded from the plant.

Satisfactory compliance. This item will be satisfied when:

a. Material and equipment not in routine use are not stored in rooms used for shell-stock storage, shucking, packing, repacking, or container storage.

b. The shell-stock storage, shucking, and packing portions of the plant are not used for other operations while shellfish are being processed.

c. No domestic animals, rodents, or fowl are permitted in shellfish-processing plants.

d. Only personnel engaged in packing operations, supervisory personnel, authorized inspectors, or other persons specifically authorized by the plant manager, are allowed in the shell-stock storage, shucking, or packing rooms during period of operation.

e. Premises are clean and free of litter and rubbish.

f. Shuckers do not go into or through the packing room for any purpose. (An exception may be made in small operations, where an employee may work in both the packing room and the shucking room. In such cases, the employee should be required to change aprons and wash his hands thoroughly before entering the packing room.)

16. Cleaning of Buildings and Equipment. Shucking benches, shucking stools, floors, and, if necessary, walls of the shellstock storage rooms and packing and shucking rooms shall be cleaned within 2 hours after the day's operations have ceased. Windows and skylights shall be kept clean. Refrigerators shall be kept clean. All equipment, utensils, and work surfaces, including the external and internal blower airlines and blower drain valves, shall be cleaned by scrubbing with water and detergent and rinsing with potable water within 2 hours after the day's operations have ceased.

Public-health reason. Clean workrooms and refrigerators reduce the chance of contaminating shellfish during shucking and processing. Shucked shellfish cannot be kept clean and safe if permitted to come into contact with equipment which has not been sanitized. Bactericidal treatment is not effective unless the equipment be first thoroughly cleaned.

The determination of adequate cleanup facilities will depend upon the method of bactericidal treatment selected (see item 17) and plant-by-plant determination of what equipment and utensils may best be washed in a sink and what equipment may best be washed "in place". Detergents and brushes, including special brushes that may be needed for cleaning equipment such as blower lines, should be available.

Sink Washing. Wash sinks should be made of impervious, nontoxic material. Sink compartments should be large enough to permit the complete immersion of the largest utensil to be sink-washed. A second compartment should be provided in the sink for clean-water rinsing between washing and bactericidal treatment, unless some other acceptable method, such as a spray rinse, be provided. In the case of bactericidal treatment by immersion in hot water (item 17a (2)), both the bactericidal treatment and rinse may be accomplished simultaneously in the second compartment. If bactericidal treatment by means of immersion in chemical solutions (item 17a (3)) be selected, a separate compartment should be provided for this operation.

Number of Compartments Required in Sink

Method of bactericidal treatment	Method of Rinse	
	Immersion	Spray
Steam cabinet	2	1
Hot water (170°F.)	2	*
Bactericidal solution	3	2

*Not applicable.

In-Place Washing. Utensils and equipment which have to be washed "in place" will require the same three steps of wash, rinse, and bactericidal treatment. A watertight container, such as a blower tank, is best washed by preparing a solution of the detergent in the container itself and using this to scrub all parts of the unit. Rinsing, preferably, should be accomplished either by complete filling or by thorough spray rinse. The bactericidal treatment methods are described in item 17.

Satisfactory compliance. This item will be satisfied when:

a. Shell-stock storage, shucking, and packing rooms are cleaned within 2 hours after the day's operations have ceased.

b. All utensils, equipment, and work surfaces, including the external and internal blower airlines below the tank's liquid level, are cleaned by scrubbing with water and detergent and rinsing with potable water within 2 hours after the day's operations have ceased.

c. Cleaned benches, blocks, and stalls are flushed or sprayed as often as necessary, and at least once each week, with a solution containing not less than 100 parts per million of available chlorine, or other disinfecting agents in effective concentrations as approved by the State regulatory authority.

d. Refrigerators are clean.

e. Adequate cleanup facilities, including sinks, bactericides, detergents, and brushes, are available within the plant. Where chemical bactericides are used, a third compartment or spray rinse must be installed to permit a clean-water rinse between washing and bactericidal treatment. (Sink compartments should be large enough to permit complete immersion of the largest utensil to be washed.)

f. All shelves, tables, and other equipment in the shucking and packing rooms are clean.

g. Wash tanks, blowers, and containers for shucked-stock holding are flushed or spray-rinsed with tapwater after each emptying. (Dismantling is not necessary.) Periodic clean-water flushing of shucking benches, utensils, table surfaces, and other equipment during working periods is recommended.

17. Bactericidal Treatment of Utensils and Equipment. All utensils and equipment in the shucking and packing rooms which come into contact with shucked shellfish shall be subjected to an effective bactericidal process at the end of each day's operation.[20]

Large equipment which might be recontaminated before use shall be cleaned at the end of each day's operation, and shall be subjected to effective bactericidal treatment immediately before use.

Returnable shipping containers, if used, are subjected to an effective bactericidal treatment process on the day they are to be used, and are protected against contamination until filled.

Satisfactory compliance. This item will be satisfied when:

a. All utensils and other equipment have been treated by one or more of the following methods:[21]

(1) Exposure for at least 15 minutes at a temperature of at least 170°F., or for at least 5 minutes at a temperature of at least 200°F., in a steam cabinet equipped with an indicating thermometer[22] located in the coldest zone. (Absence of a thermometer violates this item.)

If steam be used in the bactericidal treatment of blowers, a suitable cover and indicating thermometer are provided. A vent or valve should be installed at the bottom of large steam

20. Containers which have been subjected to bactericidal treatment should have a residual bacterial plate count of not more than 1 per milliliter of capacity, and equipment not over 100 colonies per 8 square inches (i.e., 2 per square cm.) of food-contact, in 3 out of 4 samples. (See Standard Methods for the Examination of Dairy Products for Information on apparatus and procedure for making rinse and swab counts.)

21. In medium and large shucking plants, a steam cabinet with auxiliary steam boiler is a most satisfactory type of equipment for bactericidal treatment of utensils and equipment.

22. Thermometers should be accurate to within 2°F., should have scale divisions not greater than 2°F., and should be so installed as to be easily read. Accuracy of thermometer should be checked at least once each year by the State regulatory agency.

cabinets, to permit the discharge of cold air when steam is admitted.[23]

(2) Immersion in hot water of at least 170°F. for at least 2 minutes. (An accurate indicating thermometer is provided and used.)[22, 23] Ordinarily, a booster heater is necessary for water to be maintained at 170°F.

In the bactericidal treatment of blowers by this method, the blower may first be filled with water and then brought up to 170°F. by the addition of steam. This temperature should be checked by the indicating thermometer, and the 2-minute contact period measured after reaching this value. In practice, it has been found desirable to provide a connection to, or a removable section in, the blower line above the liquid level of the tank, where steam or hot water can be introduced.

(3) Immersion for at least 2 minutes in, or exposure for at least 2 minutes to, a flow of a solution containing not less than 50 parts per million of free chlorine. All product-contact surfaces must be wetted by the bactericidal solution, and piping so treated must be filled. Bactericidal sprays containing not less than 100 parts per million of free chlorine may be used for large equipment. Bactericidal treatment with chemicals is not effective unless the surface has been thoroughly cleaned.

Bactericides other than chlorine should not be accepted by the inspector until official tests by the proper regulatory authority have demonstrated that the bactericide in question is satisfactory for use in connection with shellfish sanitation. The local inspector should consult his State health organization regarding other bactericides in use in his area, so that he may be certain he is using the proper tests for effectiveness and concentration.

b. Large items which cannot be stored in a protected place are given effective bactericidal treatment immediately before starting each day's operation.

Table 1
Amounts of Chlorine Compounds Required to Give Approximately 100 p. p. m. of Chlorine by Readily Available Measuring Devices

Volume of water (gallons)	Dry chlorine compounds—available chlorine			Liquid hypochlorite solutions—available chlorine	
	15 percent	25 percent	70 percent	1 percent	5 percent
20	5½ tbs	3½ tbs	1½ tbs	3 cups	10 tbs.
40	11 tbs	6½ tbs	2½ tbs	3 pts	1¼ cups.
60	1 cup	10 tbs	3½ tbs	4 3/4 pts	2 cups.
80	1 2/5 cups	13½ tbs	4½ tbs	6½ pts	2½ cups.
100	1 4/5 cups	1 cup	6 tbs	4 qts	3 cups.
150	2 3/4 cups	1½ cups	9 tbs	6 qts	4 3/4 cups.
200	3 3/5 cups	2 cups	12 tbs	2 gals	3 pts.

NOTE

Dry measure

1 tablespoon (tbs.)—approximately 0.3 ounce.
1 cup or ½-pint—approximately 5 ounces.

Liquid measure

1 tablespoon or 3 teaspoons—approximately 15 milliliters.
1 cup or ½-pint—approximately 16 tablespoons.

23. Steam or hot-water treatment shall not be accepted as satisfactory compliance unless the equipment or containers be completely immersed or completely exposed for the required time or longer, at the required temperature or higher, throughout the period of exposure.

18. Storage of Equipment. Equipment and utensils which have been cleaned and given bactericidal treatment shall be stored so as to be protected against contamination.

Satisfactory compliance. This item will be satisfied when the treated equipment is stored where it will be protected from contamination or unauthorized handling. (The utensils may be stored in the steam chest, in a special cabinet, or in the packing room on clean shelves, stands, tables, or racks. Storage racks should be at least 2 feet above the floor.)

19. Source of Shellfish. All shellfish shall be obtained from a source approved by an official regulatory agency.

Public-health reason. Besides the reasons discussed in part I, the following are important:

a. There is evidence that organisms of the Salmonella group, at least, will survive in shellfish for a considerable length of time after harvesting. Kelly and Arcisz ("Survival of Enteric Organisms in Shellfish," Reprint No. 3249, Vol. 69, No. 12., Dec. 1954, pp. 1205-1210, Public Health Reports) have shown that viable S. schottmuelleri will persist for at least 49 days in shell oysters, Crassostrea virginica, stored at a temperature of 40°F. However, there was little evidence of multiplication of thebacteriain the shellfish during the storage period. In the same study, it was reported that S. schottmuelleri persisted in soft clams, Myra arenaria, stored at a temperature of 40°F., throughout a normal storage period.

Other public-health hazards may result from the presence of a naturally occurring paralytic shellfish toxin in certain species of shellfish. The occurrence of this toxin is apparently related to the concentration of a dinoflagellate, Gonyaulax, in the water of the growing area. Species of shellfish which may accumulate this toxin under appropriate conditions include Mytilus californianus, Mytilus edulis, Mya arenaria, Saxidomus gigantius, Donax serra, and Modiola modiolus. The toxin occurs only in well-defined areas and, in some instances, only during certain seasons. It is not widespread over all shellfish-producing areas. (See McFarren, et al., "Public Health Significance of Paralytic Shellfish Poison," 1956 Proceedings, National Shellfisheries Assn.)

Cooking does not insure safety of shellfish since, in ordinary cooking processes, shellfish may not be sufficiently heated to insure a kill of pathogenic organisms, although a considerable reduction will take place. It has been found that oysters must be held in a water bath at 138°-142°F. for 1 hour before the coliform count is reduced to zero. Also, normal cooking processes cannot be relied upon to destroy paralytic shellfish toxin if it should be present.

The primary safeguard in the entire shellfish-sanitation program is, therefore, that of obtaining shellfish which are free of disease-causing organisms, and which contain, at most, only relatively small quantities of toxin. If shell stock from sewage polluted or highly toxic areas are shucked, then almost all of the other sanitary safeguards of the cooperative certification program will have been circumvented.

Satisfactory compliance. This item will be satisfied when all shellfish are obtained from one or more of the following sources: (a) An approved growing area; (b) a State-certified shellfish shipper; or (c) a State-approved shellfish-treatment plant.

20. Refrigeration of Shell Stock. Shell stock of shellfish species which have poor keeping qualities (such as the soft-shell clam, Mya arenaria, and the mussels, Mytilus edulis and Mytilus californianus) shall be refrigerated during shipment and holding.

Satisfactory compliance. This item will be satisfied when:

a. Shell stock of shellfish species with poor keeping qualities are stored at a temperature of 50°F. or less, but are not frozen, and when, at points of transfer, such as loading docks, shell stock are not permitted to remain unrefrigerated for prolonged periods.

b. Shell stock are protected from the sun during warm weather to the extent necessary to prevent spoilage.

21. Shucking of Shellfish. Shellfish shall be shucked in such a manner that they are not

subjected to contamination. Shell stock shall be reasonably free of mud when shucked.[24] Only live shellfish shall be shucked.

Water used in fluming or washing shell stock shall be from a source approved by the State regulatory agency. Use of overboard water must be specifically approved by the State agency, and its use limited to shellstock washing.

Public-health reason. Besides various obvious reasons, the following reasons are noted:

The bacteria count of the final pack is related to the time intervening between shucking and attainment of a temperature of approximately 45°F., i.e., the length of time the shellfish are at a temperature favorable to the rapid growth of bacteria. Factors in the shucking-room procedure which influence the length of time shucked shellfish are above 45°F. include the quality and species of the shellfish being shucked, the speed of the individual shucker, the practice of returning "overage" or "bluff" to the shuckers, the frequency with which the shucking containers are delivered to the packing room, the air temperature, and the temperature of the shell stock being shucked.

The total elapsed time which shellfish may be held on the shucking bench without causing high bacteria counts is closely related to the packing-room procedures, the size of containers into which the shucked shellfish are being packed, the temperature of blower water, the temperature of the oysters, and the method of cooling.

From the standpoint of bacteriological quality, it is preferable that the elapsed time between shucking and the attainment of a temperature of 45°F. not exceed 4 hours. More rapid cooling is very desirable.

The return of overage (bluff) from the packing room to the shucker would ordinarily result in at least a portion of the shellfish being held on the shucking bench for more than 2 hours, and would permit an undesirable growth of bacteria. When bench-grading of shellfish is practiced, it is especially important that all grades of shellfish be delivered to the packing room at least once every 2 hours when the temperature of the shellfish exceeds 45°F. To encourage frequent delivery of the shucked shellfish to the packing room, it is suggested that the shucking containers be limited to a size that an average shucker might reasonably be expected to shuck full in 1 hour.

Storage of shucked shellfish on the shucking benches for long periods of time increases the possibility of contamination of the shucked shellfish by splash or flies.

Bacteriological examination of the water in dip buckets has shown very high coliform counts. Since water from the dip bucket may be carried over into the shucked shellfish, there is a need for controlling the sanitary quality of the water.

Satisfactory compliance. This item will be satisfied when:

a. Water used for fluming or washing shell stock is obtained from a source approved by the official State regulatory agency.

b. Shell stock are reasonably free of mud when shucked.

c. Only live shellfish are shucked.

d. The use of "dip" buckets is prohibited. (Where conditions dictate the need for frequent rinsing of the shucker's hands and knife, it is recommended that water outlets be installed at the shucking bench convenient to each shucker, or that a flow-through type of dip bucket, in which the water is continually replaced by clean tapwater, be installed.)

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24. The primary responsibility for washing the shellfish free of mud is placed on the harvesters. However, this does not relieve the plant operator of responsibility for compliance with this item. (See section A, item 2.)

e. Shucking containers are rinsed with running tapwater before each filling.[25]
f. The return of overage (bluff) from the packing room is not permitted.

22. Shell Disposal. Shells from which meats have been removed shall be removed promptly from the shucking room.

Satisfactory compliance. This item will be satisfied when shells are promptly removed from the shucking room to prevent interference with the sanitary operation of the plant. Any method of shell removal which results in the prompt removal of shell without contaminating the shucked product is acceptable. These methods include, but are not limited to, conveyors, baskets, barrels, wheelbarrows, or shell drop-holes. (It is recommended that unused portions of body meats, such as clam siphons, not be disposed of with shells. Fly-control measures may be necessary in the vicinity of shell-piles.)

23. Handling of Single-Service Containers. All single-service containers shall be stored and handled in a sanitary manner and, where necessary, shall be given bactericidal treatment immediately prior to filling.

Satisfactory compliance. This item will be satisfied when:
a. Single-service containers and covers are kept in original cartons until used, and are kept clean and dry.
b. Containers which may have been contaminated during storage are cleaned and given bactericidal treatment immediately prior to filling, or are discarded.
c. Plant employees use every reasonable precaution to prevent the food-contact surfaces of containers from coming into contact with their person or clothing.
d. Container-storage rooms are kept clean and free of rodent and insect infestation; containers are so stored that the presence of rodents may be easily detected;[26] and container-storage rooms are not used as general storerooms for unused equipment and materials.
e. Single-service containers in the packing room are kept on stands or tables at least 2 feet above the floor, and are protected against contamination from splash.

24. Packing of Shucked Shellfish. Shucked shellfish shall be packed without exposing them to contamination. Shucked shellfish shall be packed and shipped in clean, single-service containers made of impervious materials, or in clean, properly designed, returnable containers[27] so sealed that tampering can be detected. Each individual package of fresh or frozen shellfish shall have permanently recorded on the package or label, so as to be easily visible, the packer's, repacker's, or distributor's name and address, and the packer's or repacker's certificate number preceded by the abbreviated name of the State. Containers holding 1 gallon or more shall have the identification on the container wall, unless the cover becomes an integral part of the container during the sealing process.

Each State shall establish a code-dating system[28] which shall be utilized by all shucker-

25. Food and Drug Administration requirements limit the amount of water in the shucking containers to one-fourth of the capacity of the container.
26. Containers should be stored on open racks or pallets at least 8 inches above the floor and 18 inches away from the walls.
27. Returnable containers will be accepted only for interplant shipment of shucked shellfish.
28. A five-digit number and letter system should be established which will reflect the year, the month, the day of the month, and the morning or afternoon in which the shellfish were packed or repacked. Larger packers may wish to indicate morning or afternoon packing by using the letter "A" or "P" in their code system. Example: 1965, 10th month (October), 12th day of month, morning=51012 A.
It is recommended that repackers be required to precede their code-dating digits with the letter "R" to indicate the product is repacked.

packers and repackers in that state to indicate the date of packing or repacking of all fresh and frozen shucked shellfish.

Satisfactory compliance. This item will be satisfied when:

a. Skimmer tables are so located that they will not receive drainage from the delivery window.

b. Shuckers do not place shucking containers on skimmers.

c. Shellfish are not exposed to contamination during packaging.

d. Containers are closed as soon after filling as is feasible.

e. The name and address of the packer, repacker, or distributor, and the certificate number, preceded by the abbreviated name of the State, of the packer or repacker, are permanently recorded on the package so as to be easily visible. Wording, such as "Packed for" or "Distributed by," is used wherever necessary to clarify the name on the label. Containers holding 1 gallon or more have the identification on the side wall, rather than on the cover, unless the cover becomes an integral part of the container during the sealing process.[29] (The presence of containers or covers with a plant number other than that on the unexpired certificate for the plant will be considered a violation of this item. Packing into containers with other plant certification numbers is not permitted. Recording identification information on containers by use of a rubber stamp will not be acceptable for compliance with this item.) Returnable shipping containers may be identified with tags of at least 2-5/8 x 5-1/4 inches in size and made of substantial water-proof stock.

f. The date or code of packing is placed on each package of frozen shellfish, but this information need not be on the outer wrap. (The packaging code should be made available at the request of the State shellfish-regulatory authority. Code-dating of nonfrozen products is also recommended.)

25. Refrigeration of Shucked Shellfish. Shucked shellfish shall be cooled to an internal temperature of 45°F. or less within 4 hours after shucking. Storage temperatures shall not exceed 45°F. Storage at 34-40°F. is strongly recommended.

A temperature of 0°F. or less shall be maintained in the frozen-storage rooms.

Public-health reason. Shucked shellfish are an excellent medium for the growth of bacteria. Thus, it is very important that the packaged shellfish be cooled promptly, so that bacteria will not multiply. Also, temperatures above 45°F. may accelerate physical deterioration and spoilage of shucked stock. Alternate freezing and thawing of shellfish may cause deterioration and spoilage.

Investigations indicate that keeping qualities of shucked oysters are enhanced when a storage temperature of 2° to 4°C. (35°to 39.2°F.) is used.

Research by the Public Health Service with Crassostrea virginica and Crassostrea gigas stored in ice and at 37.5°F. sustained slight increases in coliform MPN's during the first five days of storage. After the storage period of five days, there was a continuous increase in MPN values until the 25th day, at which time the coliform MPN's exceeded the original values by at least 50 times. Oysters from the same lots stored at 50°F. sustained a continuous increase in coliform MPN's exceeding 1000 times the original count within five days.

In the same studies, oysters stored in ice and at 37.5° F. sustained only slight increases in standard plate counts after being stored for five days. However, with a storage temperature of 50°F. the same oysters sustained plate count increases which exceeded 180 times their original count within five days.

29. Additional information on product quality, quantity, and identification may be required by Federal and/or State laws.

The fecal coliform MPN's decreased slightly from their original MPN values during storage in ice, at 37.5°F. and at 50°F., with the exception that there was a frequent increase in fecal coliform MPN's at the 50°F. storage temperature.

It was concluded that to avoid adverse bacterial multiplication it is necessary to refrigerate shucked oysters immediately after shucking to 45°F. or lower.

Satisfactory compliance. This item will be satisfied when:

a. Shucked shellfish are cooled to an internal temperature of 45°F. or less within 5 hours after shucking, and are stored and shipped under similar temperature conditions. (One-gallon containers will ordinarily have to be stored in crushed or flaked ice immediately after packing, to attain this degree of cooling. For containers holding more than 1 gallon, shellfish will ordinarily require cooling prior to placement in containers.)

b. Packaged shellfish to be frozen are properly stacked to insure rapid freezing, and are frozen at an ambient air temperature of 0°F. or less, with packages frozen solid within 12 hours after the start of freezing; and frozen shellfish are handled in such a manner as to remain frozen solid, and are held at 0°F. or less.[30]

26. Ice. Ice shall be obtained from a source specifically approved by the State regulatory agency, and shall be stored and handled in a clean manner.

Satisfactory compliance. This item will be satisfied when:

a. Ice is manufactured in an establishment or machine approved by the proper State regulatory authority.

b. Ice is stored and handled in such a manner that it will not be contaminated.

c. Ice, other than that manufactured in the shellfish-processing establishment, is washed before use.

27. Records. Complete and accurate records shall be kept by every shellfish dealer.

Public-health reason. In case of an outbreak of disease attributable to shellfish, it is necessary that health departments be able to determine the source of contamination, and thereby to prevent any further outbreaks from this source. This can be done most effectively by following the course of a shipment, through all the various dealers who have handled it, back to the point of origin by means of records kept by the shellfish dealers.

Satisfactory compliance. This item will be satisfied when each shucker-packer, repacker, shellstock shipper, or reshipper establishes and maintains a ledger record or record system satisfactory to the State control agency indicating from whom shellfish were purchased or secured; the date purchased or secured; State designated areas from which the shellfish were harvested; and the names and addresses of persons to whom shellfish were sold. Failure to establish and maintain adequate records shall result in refusal of State agencies to certify shucker-packers for interstate certification.

30. It is recommended that freezing and frozen-storage compartments be equipped with at least the following equipment: (1) Automatic temperature-regulating control; (2) an indicating thermometer, so installed as to indicate accurately the temperature within the storage compartment; and, (3) except for plate freezers, a recording thermometer installed on each freezing or storage compartment in such a manner as to record accurately the temperature within the compartment at all times. Recording-thermometer charts should be retained for at least 1 year.

28. Health of Personnel. Any person known to be infected with any disease in a communicable form, or to be a carrier of any disease which can be transmitted through the handling of shellfish, or who has an infected wound or open lesion on any exposed portion of his body, shall be excluded from the shucking or packing plant. An owner or manager who has reason to suspect that any employee has contracted a communicable disease shall immediately notify the proper health officials. Pending appropriate action by the health officials, said employee shall be excluded from the plant.

Satisfactory compliance. This item will be satisfied when:

a. Persons with infected wounds or open lesions on the exposed portions of their bodies, and those who are known to be carriers of, or infected with, typhoid fever, dysentery, or other communicable diseases likely to be transmitted by shucked shellfish, are excluded from the plant.

b. Daily observations of employees are made by the supervisor, with reasonable inquiries being made when signs of illness appear.

c. Upon an inquiry indicating the possibility of a communicable disease, the ill employee is excluded from the plant pending clearance by the health officials.

d. Employees having diarrhea or sore throat promptly report this to the manager.

29. Supervision. The management shall designate a reliable individual to be accountable for compliance with the items of this manual having to do with plant and personnel cleanliness.

Satisfactory compliance. This item will be satisfied when a reliable individual has been designated by the management to supervise the activities enumerated in section B, items 16, 28, and 30, and when there is evidence that he has been executing these duties. Designation of such an individual does not relieve management of responsibility for compliance with these items.

30. Cleanliness of Employees. Employees shall wash their hands with soap and water before beginning work, and again after each interruption. (Supervision of handwashing is a specific responsibility of management, section B, item 29.)

When manual handling of shucked shellfish becomes necessary, sanitized rubber gloves shall be worn, or the hands shall be washed and disinfected immediately before such manual handling.

Finger cots, gloves, and/or shields, if worn by shuckers, shall be sanitized as often as necessary and at least twice daily. (Use of waterproof finger cots or shields is recommended as preferable to those made of an absorbent material.) Any person who handles shucked shellfish shall wear a clean apron or coat.

Employees shall not use tobacco in any form in the rooms in which shellfish are shucked or packed.

Satisfactory compliance. This item will be satisfied when:

a. Clean aprons or coats are worn by any persons handling shucked shellfish.

b. Aprons or coats not in use are stored in a room or locker provided for this purpose.

c. Finger cots, gloves, and/or shields, if worn by shuckers, are sanitized as often as necessary and at least twice daily, and are properly stored until used. (See section B, item 18.)

d. Sanitized rubber gloves are worn during, or the hands are washed and disinfected immediately before, any manual handling of the shucked shellfish. (A bucket or pan of the bactericidal solution should be present in the packing room during periods of operation.)

e. There is no evidence of spitting, or of the use of any form of tobacco, by employees in rooms in which shellfish are shucked or packed.

f. Employees wash their hands with soap and water before beginning work and after each interruption, and utensil sinks are not used for handwashing.

Section C

Packing and Shipping Shell Stock

A shell-stock shipper deals only in shellfish which are still in the shell; hence, his plant

sanitation requirements are not so extensive as those of a shucker-packer or repacker. A shipper holding only a shellstock certificate shall not shuck shellfish or repack shucked shellfish. Operators of "buy" boats and "buy" trucks shall be considered shellstock shippers.

Shellfish in the possession of a shellstock shipper shall be protected against contamination. The shellstock shipper shall keep records of his purchases and sales, and shall tag shellstock shipments so that they may be identified.

To effectuate the needed sanitary safeguards, the shellstock shipper shall comply with items 1 and 2 below, and with the several items of section B indicated in table 2:[31]

Table 2

Shell-stock operation type	Applicable Item Sect. A		Applicable Item - Sect. B											
	1	3	1	3	9	10	11	12	15	19	20	25	27	28
Shore establishment* buys, stores, packs	-	-	x	x	a	a,d,f,g,h, i,j,k,m**	x	x	a,c,d, e	x	x	x***	x	x
Harvests or Buy Boats, all operations on boat	x	x	-	-	-	-	-	-	a,c,d	x	x	-	x	x
Buy Trucks, all operations on truck	c,e,f	-	-	-	-	-	-	-	a,c,d	x	x	-	x	x

* = If shore establishment operates boats or trucks requirements for Buy Boats and Buy Trucks are also applicable.
** = Item b also applies to pressure systems.
*** = Applies if shucked shellfish be handled.

x = Required
- = Not required

1. Washing of Shell Stock. Shell stock shall be reasonably free of mud at the time of shipment.

Satisfactory compliance. This item will be satisfied when:

a. Shell stock are reasonably free of mud at the time of shipment. The qualifications applicable to washing of shell stock under section A, item 2a, also apply to this item.

b. Water used for shellstock washing is from a source approved by the official State regulatory authority.

2. Packing and Shipping of Shell Stock. Shell stock shall be packed and shipped in clean containers, under conditions which will prevent contamination. When consigned in bulk, shell stock shall be shipped in clean conveyances, under conditions which will prevent contamination.

Shell stock in transit shall be identified by a tag or label fastened to each shipping container and bearing the number of the shipper, his name and address, the name and address of the consignee, and the kind and quantity of shell stock in the container. The following classes of shell stock shippers shall be exempt from this requirement: Harvesting Only; Buy Boats; and Buy Boats with Storage on the Boats.

Satisfactory compliance. This item will be satisfied when:

a. Shipping containers and vehicles are clean.

b. Tags at least 2-5/8 x 5-1/4 inches in size, and made of substantial, waterproof stock, and carrying the name, address, and number of the dealer, the name and address of the

31. All items may not be applicable to every shellstock shipper.

consignee, and the kind and quantity of the shell stock, are securely fastened to each individual container of shell stock. (Bulk shipments,"e.g., unpackaged," of shell stock to a certified shipper require only a single tag or bill of lading which gives the required information.)

Section D

Repacking of Shellfish

The packaging of shucked shellfish in plants other than those in which they were initially shucked exposes the shucked shellfish to additional handling and increases the possibility of contamination. Combining inonepack shucked shellfish from more than one dealer permits the possibility of contamination of the entire pack if shellfish from any one of the dealers should be contaminated. When repacking is practiced, tracing of shellfish to the source is difficult.

Where repacking is practiced, it shall be done in accordance with the requirements of table 3 and the items which follow in this section.

Table 3

Item number in Section B	Item	Applicable satisfactory-compliance items
2	Plant arrangement	a, d, and e.
4	Floors	all items.
5	Walls and ceilings	all items.
6	Fly-control measures	all items.
7	Lighting	all items.
8	Heating and ventilation.	b.
9	Water supply	all items.
10	Plumbing and related facilities.	all items.
11	Sewage disposal	all items.
12	Rodent control	all items.
14	Construction of utensils and equipment.	all items.
15	General cleanliness	all items.
16	Cleaning of buildings and equipment.	a, b, d, e, f, and g.
17	Bactericidal treatment of utensils and equipment.	all items.
18	Storage of equipment	all items.
19	Source of shellfish	all items.
23	Handling of single-service containers.	all items.
24	Packing of shucked shellfish	c, d, e, f, and g.
26	Ice	all items.
27	Records	all items.
28	Health of personnel	all items.
29	Supervision	all items.
30	Cleanliness of employees	a, b, d, e, and f.

1. Shucked Shellfish Intended for Repacking. Shucked shellfish to be repacked shall be received at the repacking plant in approved shipping containers at a temperature of 45°F. or less. Frozen shellfish which have thawed shall not be repacked or repackaged.

Public-health reason. Shellfish which are not shipped in properly sealed, easily cleanable containers may become contaminated. Shellfish which have not been properly refrigerated may have excessively high bacteria counts.

If frozen shellfish are thawed during repacking, high bacteria counts in the final pack may result.

Satisfactory compliance. This item will be satisfied when:

a. All shucked shellfish are received in properly designed[32] containers. (Returnable containers should be so sealed that any tampering will be evident.)

b. Shellfish are received at a temperature of 45°F. or less. Frozen shellfish which have thawed are not repacked or repackaged.

2. Refrigeration During Repacking. The temperature of the shellfish shall not exceed 45°F. during the repacking process. Frozen shellfish shall not be thawed during the repacking process.

Satisfactory compliance. This item will be satisfied when:

a. The internal temperature of nonfrozen shellfish being repacked does not exceed 45°F. during the repacking process. (This may be accomplished by expeditious handling, by continuous refrigeration of the shellfish being repacked, or by the provision of a refrigerated room for the repacking operation.)

b. Frozen shellfish are not thawed during the repacking process.

3. Cleaning of Returnable Shipping Containers. Returnable shipping containers shall be thoroughly cleaned as soon after emptying as is practicable.

Section E

Reshippers

Persons who reship shellfish from certified shellstock shippers, shucker-packers, or repackers to other certified shippers or to final consumers should be licensed and certified as reshippers. Use of this shipper classification is left to the option of the State. (A reshipper is not permitted to shuck shellfish, nor to repack shucked shellfish.) Requirements for a reshipper depend upon the type of product handled and the methods of operation. If shell stock be handled, the applicable requirements outlined for a shellstock dealer must be met (section C). If only shucked shellfish be handled, the required items are: section B, item 19(Source), item 25 (refrigeration), and item 27 (Records).

Appendix A

Inspection of Certified Shellfish Shippers

General: Section A-2 of Part I specifies that shellfish shippers certified by States under the Cooperative Program shall meet the construction requirements of Part II of this manual prior

Table 4

Percentage Values for Use in Establishing Sanitation Ratings of Shucker-Packers by Use of Standardized Inspection Report, PHS-769

Section	Item Number	Item	Percent Values
B	1	Wet Storage----------	25
	19	Source of Shellfish----------	25
C	1	Shell Stock Washing----------	1
	2	Shell Stock Shipping Container--------	2
D	1	Shellfish for Repacking----------	2
	2	Refrigeration----------	4
		Frozen Shellfish----------	1
	3	Returnable Containers, Cleaned--------	1

32. See section B, item 14.

to certification, and shall maintain satisfactory sanitary conditions during periods of operation. Establishments not meeting these two requirements will not be eligible for inclusion on the Public Health Service list of State certified shellfish shippers.

Plants will be considered as meeting the basic sanitary standards of part II of this manual when the two following conditions are met: (1) the same sanitation item is not violated repeatedly, and (2) a sanitation rating of at least 80 percent, as determined by a standardized inspection procedure, is achieved.

Sanitation ratings of shucker-packer and repacker establishments should be determined by use of an inspection report equivalent to PHS-769. The percentage values assigned to each item are shown on the sample inspection report. Percent values are not shown for items B-1, B-19, C-1, C-2, D-1, D-2, and D-3 since any violations of these items are applied against the tentative percentage rating for the plant. Percentage values for these items are given in Table 4 Section C of the inspection report (PHS-769) should not be used unless the shucker-packer ships a portion of his product in the shell. Section D of the inspection report (PHS-769) should not be used unless the shucker-packer also repacks shellfish.

Sanitation ratings for shell stock shippers should be determined by use of an inspection report equivalent to the "Shell Stock Shipper Inspection Report". The percentage values assigned to each item are shown on the sample inspection report.

Sanitation Ratings for Shucker-Packers: In computing a sanitation rating for a shucker-packer the violations recorded under section B on the inspection report should be totaled using the indicated percentage values. This total, when subtracted from 100, will give a tentative percentage sanitation rating. If items B-1 or B-19 be violated an additional 25 percent or 50 percent should be subtracted from the tentative rating (See table 4. Similarly, any violations recorded under sections C and D should also be subtracted according to the Table 4 schedule.

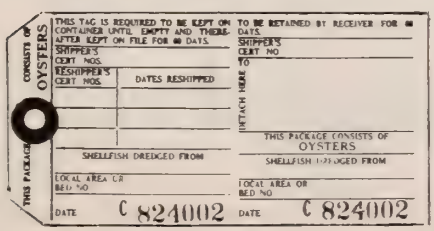
Sanitation Ratings for Repackers: The instructions for rating a shucker-packer should be followed in rating a repacker except that section B items not applicable to the operation of the repacker should be indicated on the inspection report and should be taken into consideration in computing the tentative sanitation rating according to the following formula:

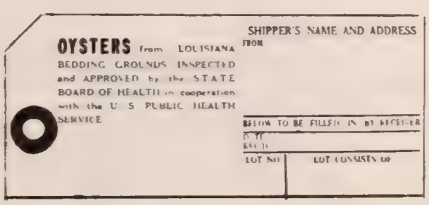
$$\text{Tentative sanitation rating (percent)} = \frac{\text{(Percent compliance Section B) (100)}}{\text{(Percentage of Section B applicable)}}$$

Any violations noted for items B-1, B-19, C-1, C-2, D-1, D-2, or D-3 should be subtracted from the tentative rating according to the table 4 schedule to obtain a final rating.

Sanitation Ratings for Shell Stock Shippers: The required physical facilities and operating procedures for shell stock shippers varies with the type of establishment. Therefore, all items on the inspection report will not apply to every shipper. (See section C, part II.) In completing the inspection report those items which are not applicable to the particular shipper should be so indicated. These "not applicable" items should be taken into consideration in computing the sanitation rating for the shipper according to the following formula:

$$\text{Sanitation rating (percent)} = \frac{\text{(Percent compliance) (100)}}{\text{(Percent applicable)}}$$


THIS TAG IS REQUIRED TO BE KEPT ON CONTAINER UNTIL EMPTY AND THEREAFTER KEPT ON FILE FOR 60 DAYS.
TO BE RETAINED BY RECEIVER FOR 60 DAYS.
SHIPPER'S CERT NOS.
DATES RESHIPPED
SHELLFISH DREDGED FROM
LOCAL AREA OR BED NO.
DATE
C 824002
THIS PACKAGE CONSISTS OF OYSTERS


OYSTERS from LOUISIANA BEDDING GROUNDS INSPECTED and APPROVED by the STATE BOARD OF HEALTH in cooperation with the U. S. PUBLIC HEALTH SERVICE
SHIPPER'S NAME AND ADDRESS
FROM
LOT NO.
LOT CONSISTS OF

PHS–769–3
Rev 3–63

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

Form Approved:
Budget Bureau No. 68–R633

SHELL STOCK SHIPPER OR RESHIPPER INSPECTION REPORT

PLANT NAME AND LOCATION

CERTIFICATE NO

PRODUCT

NUMBER OF EMPLOYEES

Items not applicable to shipper being inspected should be indicated in appropriate block as "NA"

SECTION A		NA
1 BOATS AND TRUCKS		
Construction satisfactory	1	
Kept clean, containers clean	1	
Cleaned after relaying operations	1	
3 BODY WASTE DISPOSALS		
Not discharged in harvesting area	1	
Soil cans — used for purpose intended, secured, proper disposal	1	
SECTION B		
1 WET STORAGE		
Protected, State Approved	20	
3 SHELL STOCK STORAGE		
Floors impervious, graded to drain	2	
Walls, smooth, well-constructed	1	
Conveyances easily-cleanable, clean	1	
Not used as a passageway	1	
Floor drain protected against backflow	1	
9 WATER SUPPLY		
Safe, adequate quantity	15	
10 PLUMBING AND RELATED FACILITIES		
Approved, no cross-connections	3	
Lavatories, soap, single-service towels	2	
Handwashing signs posted	1	
Toilet rooms clean, good repair, ventilated, lighted, supply of toilet tissue	2	
Toilet room doors self-closing, tight	1	
No overhead drains	3	
11 SEWAGE DISPOSAL		
Satisfactory	2	
12 RODENT CONTROL		
Rodent free, proper construction	2	
Safe use and storage of rodenticides	1	
13 GENERAL CLEANLINESS		
No miscellaneous equipment or material	2	
No animals, fowl, unauthorized persons	1	

15 GENERAL CLEANLINESS (Cont'd)		NA
Premises clean, no rubbish	1	
19 SOURCE OF SHELLFISH		
Approved	20	
20 SHELL STOCK COOLING		
Refrigerated or protected as necessary	2	
25 REFRIGERATION OF SHUCKED SHELLFISH		
Internal temperature of stored shellfish 45° or less	1	
Frozen shellfish storage 0° or less	1	
27 RECORDS COMPLETE, ACCURATE	3	
28 PERSONNEL HEALTH		
Infected persons and carriers excluded	3	
SECTION C		
1 WASHING SHELL STOCK		
Shell stock clean at time of shipment	1	
Wash water from approved sources (See item 9)		
2 PACKING AND SHIPPING SHELL STOCK		
Shipping containers clean	1	
Shipments properly identified	1	
SECTION E (Applies only to reshippers)		
1 SOURCE (Sec B Item 19)	25	
2 REFRIGERATION (Sec. B, Item 25)		
Internal temperature 45° or less	25	
Frozen shellfish 0° or less	25	
3 RECORDS (Sec. B Item 27)	25	

REMARKS

DATE

SANITARIAN

(Sections and item numbers refer to PHS Publication 33 Part II Rev 1965)

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

Form Approved:
Budget Bureau No. 68–R633

SHUCKING-PACKING PLANT INSPECTION REPORT

PLANT NAME AND LOCATION

CERTIFICATE NO

PRODUCT

NUMBER OF SHUCKERS

SECTION B (Shucking-Packing)	
1 WET STORAGE	
Protected, State approved	*
2 PLANT ARRANGEMENT	
Not subject to flooding	10
Separate shucking and packing rooms	10
Proper delivery window	05
Adequate packing & clothing rooms	10
3 DRY STORAGE OF SHELL STOCK	
Floors, impervious, graded to drain	20
Walls, smooth, well-constructed	05
Conveyances easily-cleanable, clean	05
Not used as passageway	05
Floor drain protected against backflow	05
4 FLOORS:	
Impervious, smooth, graded to drain	10
5 WALLS AND CEILINGS	
Smooth, washable, light-colored	20
6 FLY CONTROL MEASURES	
Adequate screens or fans, self-closing, outward-opening screen doors	15
Approved internal fly-control measures	10
Free from flies	10
7 LIGHTING	
Ample, properly distributed	20
8 HEATING AND VENTILATION	
Comfortable temperature, well ventilated	05
9 WATER SUPPLY	
Safe, adequate quantity	150
Outlet in each room	05
Ample, regulated, hot water supply	20
Hot & cold water at each sink vat	05
10 PLUMBING AND RELATED FACILITIES	
Approved, no cross-connections	60
Adequate number and location of lavatories, hot and cold water, mixing valves, soap, single-service towels	20
Handwashing signs posted	05
Adequate number and location of toilets, clean, good repair, ventilated, lighted, supply of toilet tissue	20
Toilet room doors, self-closing, tight	10
No overhead drains	05
11 SEWAGE DISPOSAL Satisfactory	10
12 RODENT CONTROL	
Rodent free, proper construction	15
Safe use and storage of rodenticides	10

13 CONSTRUCTION OF BENCHES	
Smooth, impervious, self-draining	20
Blocks easily cleanable, non-toxic	05
Stalls & stools cleanable, painted	05
No attached padding on stools	05
14 EQUIPMENT CONSTRUCTION	
Material, smooth surfaces & joints, good repair, easily cleanable, equipment installed complies sub-item 1	25
Container rims 2' above floor	05
Blower not connected directly to sewer	05
Blower air intake protected	05
15 GENERAL CLEANLINESS	
No miscellaneous equipment or material	10
Plant used only for shellfish	05
No animals, fowl, unauthorized persons	10
Premises clean, no rubbish	05
Shuckers do not go into packing room	05
16 CLEANING	
Building & equipment cleaned within 2 hrs	20
Benches and blocks disinfected weekly	05
Sinks, bactericides, detergents, and brushes	05
Blowers and tanks rinsed between uses	05
Refrigerators clean	05
17 BACTERICIDAL TREATMENT OF EQUIPMENT Approved	20
18 STORAGE OF EQUIPMENT	
Treated equipment properly stored	15
19 SOURCE OF SHELLFISH	
Approved	*
20 SHELL STOCK COOLING	
Refrigerated or protected as necessary	10
21 SHUCKING SHELLFISH	
Wash water from approved source (See item 9)	*
Shell stock free of mud	10
Bluff not returned	20
Dip buckets not used	05
Shucking containers rinsed after each use	05
22 SHELL DISPOSAL Prompt	05
23 SINGLE-SERVICE CONTAINERS	
Store rooms clean, no rodents, trash, insects	15
Kept clean and dry until used	15
Contaminated containers sanitized or discarded	10

24 PACKING SHUCKED SHELLFISH:	
Shellfish not contaminated during packing	10
Containers closed as soon as feasible	10
Clean, properly-designed containers	05
Containers identified, Code-dated	10
25 COOLING SHUCKED SHELLFISH	
Cooled to 45° in 5 hrs	25
Stored at 45° or less	25
Frozen and stored at 0° or less	05
26 ICE	
From approved source, protected from contamination, washed	15
27 RECORDS Complete, accurate	15
28 PERSONNEL HEALTH	
Infected persons and carriers excluded	15
29 SUPERVISION Effective	30
30 CLEANLINESS OF EMPLOYEES	
Clean aprons or coats, properly stored	10
Finger cots sanitized, no tobacco used	05
Packing-room workers wear rubber gloves or wash and disinfect hands	20
Handwashing by employees	20
SECTION C (SHELL STOCK)	
1 WASHING SHELL STOCK	
Shell stock clean at time of shipment	*
Wash water from approved source (See item 9)	
2 SHIPPING SHELL STOCK	
Shipping containers clean, identified	*
SECTION D (REPACKING)	
1 SHELLFISH FOR REPACKING	
In approved containers at 45° or less	*
2 REFRIGERATION DURING REPACKING	
Temperature does not exceed 45°	*
Frozen shellfish not thawed	*
3 CLEANING OF RETURNABLE CONTAINERS	
Cleaned soon after emptying	*

REMARKS

DATE

SANITARIAN

*These items not included in computation of initial sanitation rating for Shucker-Packers

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Inspection of Canned Shrimp and Oysters

In 1935, the United States Food and Drug Act was amended to authorize the Federal Security Administration* to assign inspectors to supervise plant operations of any packer of seafood who applies for this service, pays the costs, and agrees to comply with sanitation, labelling and other requirements. The amendment is known as Section 10A of the Act, or the Seafood Amendment. The 1944 and 1945 Appropriations Acts, Public Law 373, and Public Law 124, refer to this section as Section 702A of the Food, Drug and Cosmetic Act of 1938. Under the above authority, the regulations for canned shrimp and oysters were drafted. The regulations for canned shrimp were promulgated in 1941 and those for canned oysters in 1944. Each set of regulations is subdivided into 14 sections with identical titles. A large part of these two sets of regulations are identical. The text below is an amalgamation of both sets of regulations into one set. The exact text of the original regulations is therefore only partially maintained.

Federal Regulations for the Inspection of Canned Shrimp and Canned Oysters.

Application for Inspection Service

Application for inspection service on canned shrimp or canned oysters, under the provisions of Section 10A of the Federal Food and Drug Act, must be on forms supplied by the Federal Food and Drug Administration. Applications for shrimp inspection must be filed on or before June 1, each year, and for oyster inspection no less than 60 days preceding the opening date of the canning as set by the responsible State agency. A separate application must be made for each inspection period in each establishment in which the service is applied for. Each application for an initial inspection must be accompanied by an advance deposit.

Granting or Refusing Inspection Service; Cancellation of Application.

The Secretary of the Department of Health, Education and Welfare may or may not grant the inspection service applied for, depending on the applicant's compliance to the sanitary or other requirements. In case of refusal, the applicant's payment is returned less any expenses incurred by the Secretary. The applicant may withdraw his application before an inspector is assigned his establishment, in which case, the Secretary will return his payment less expenses incurred.

Inspection Periods

The initial shrimp inspection period is 9 months, and for oysters 4 months. Extension of the inspection period may be granted if applied for at least 2 weeks before close of preceding period and accompanied by a deposit. Each initial inspection period will begin on or after July 1 and not later than Sept. 15 and will not extend beyond June 30 of any year. The inspection service is continuous throughout the inspection period except when canning is suspended as a result of enforcement of the State Conservation Laws, in which case the inspection period is lengthened to compensate for the suspended inspection time.

Assignment of Inspectors.

An initial assignment of at least one inspector is made to each establishment in which inspection service is granted. Thereafter the number of inspectors assigned to each establishment is adjusted to the number required for the continuous and efficient inspection. Any inspector must have free access at all times to all parts of the establishment and to all fishing and freight boats and other conveyances used in obtaining or transporting oysters and shrimp to such establishment.

Uninspected Shrimp and Oysters Excluded from Inspected Establishments

No establishment to which inspection service has been granted will at any time thereafter can shrimp or oysters which have not been inspected, or handle or store in such establishment any canned shrimp or oysters which have not been so inspected, but certificates of inspection will be issued under these regulations only on canned shrimp and canned oysters.

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*Now, the Department of Health, Education, and Welfare.

General Requirements for Plant and Equipment.

(a) All exterior openings of the cannery including those of shucking sheds shall be adequately screened, and roofs and exterior walls shall be tight. When necessary, fly traps or other approved insect control devices shall be installed.

(b) Picking or shucking and packing rooms shall be separate, and fixtures and equipment thereof shall be so constructed and arranged as to permit thorough cleaning. Such rooms or sheds shall be adequately lighted and ventilated and the floors thereof shall be tight and arranged for thorough cleaning and proper drainage. Blanching tanks shall not be located in picking room. Open drains from picking room or shucking shed shall not enter packing or blanching room. If picking room or shucking shed and packing rooms be in separate buildings, such buildings shall not be more than 100 yards apart unless adequate provisions be made to enable efficient inspection.

(c) All surfaces of tanks, belts, tables, flumes, utensils, washers, and other equipment with which either picked or unpicked shrimp or shucked or unshucked oysters come in contact after delivery to the establishment, shall be of metal other than lead, or of other nonporous and easily cleanable material. Metal seams shall be smoothly soldered. Shucking tables shall be so constructed as to preclude contamination of working surfaces or products thereon from foot traffic or wheelbarrows or other containers used in delivering steamed oysters to such tables.

(d) Adequate supplies of steam and clean, unpolluted running water shall be provided for washing, cleaning, and otherwise maintaining the establishment in a sanitary condition.

(e) Adequate toilet facilities of sanitary type shall be provided.

(f) An adequate number of sanitary wash basins, with liquid or powdered soap, shall be provided in both the picking and packing rooms. Paper towels shall be provided in the packing room.

(g) Signs requiring employees handling shrimp to wash their hands after each absence from post of duty shall be conspicuously posted in the packing and picking rooms and elsewhere about the cannery as conditions require.

(h) Suitable space and facilities shall be provided for the inspector to prepare records and examine samples, and for the safekeeping of records and equipment.

(i) One or more suitable washing devices and one or more suitable inspection belts shall be installed for the washing and subsequent inspection of the shrimp before delivery to the picking tables.

(j) Suitable containers, flumes, chutes, or conveyors shall be provided for removal of offal from picking room.

(k) Picking tables shall be equipped with flumes supplied with clean, unpolluted water for removing the picked shrimp.

(l) Equipment shall be provided for code marking cans or other immediate containers.

(m) An automatic container counting device shall be installed in each cannery line.

(n) Suitable means shall be provided for removal of shells and debris from shucking shed.

(o) One or more suitable washing devices and one or more suitable inspection belts shall be installed for the washing and subsequent inspection of the oysters before delivery for steaming or other means of opening.

(p) Shucking knives may be maintained by the individual owner and shall be thoroughly washed with soap and water and chlorinated before use each day. Chlorine solution shall be maintained at a strength of 200 parts per million.

(q) If steam boxes be used for opening the oysters, they shall be provided with adequate steam inlets, exhausts, drains, a safety valve, and a pressure gauge.

(r) Suitable devices shall be provided for washing the shucked oysters and for their subsequent drainage.

(s) One or more suitable devices shall be provided for the removal of shell and grit from the shucked oysters.

(t) One or more suitable inspection belts shall be installed for the inspection of shucked oysters.

(u) Each processing retort shall be fitted with at least the following equipment:

(1) An automatic control for regulating temperatures.

(2) An indicating mercury thermometer of a range from 170° F. to 270° F. with scale divisions not greater than 2°. For steam cook such thermometers shall be installed either within a fitting attached to the shell of the retort or within the door or shell of the retort. For water cook such thermometers shall be installed in the door or shell of the retort below the water level. If the thermometer be installed within a fitting such fitting shall communicate with the chamber of the retort through an opening at least 1 inch in diameter. Such fitting shall be equipped with a bleeder at least 1/8 inch in diameter. If the thermometer be installed within the door or shell of the retort the bulb shall project at least two-thirds of its length into the principal chamber thereof.

(3) A recording thermometer of a range of 170° F. to 270° F. with scale divisions not greater than 2°. The bulb of such thermometer shall be installed as prescribed for the indicating mercury thermometer. The case which houses the charts and recording mechanism shall be provided with an approved lock, all keys to which shall be in the sole custody of the inspector.

(4) A pressure gauge of a range from 0 to 30 pounds with scale divisions not greater than 1 pound. Such gauge shall be connected to the chamber of the retort by a short gooseneck tube. The gauge shall be not more than 4 inches higher than the gooseneck.

(5) For steam cook, a blow-off vent of at least 3/4 inch inside diameter in the top of the retort.

(6) For steam cook, a 1/8 inch diameter bleeder in top of retort.

(7) For steam cook, a baffle plate in the base of the retort, unless retort baskets with perforated base plates be provided.

General Operating Conditions:

(a) The decks and holds of boats, tonging or dredging oysters, or catching shrimp for, or transporting shrimp or oysters to, an inspected establishment, and the bodies of other conveyances so transporting shrimp or oysters shall be kept in a sanitary condition. When necessary the shrimp or oysters shall be iced down immediately after they are caught and shall be kept adequately refrigerated until delivery to cannery.

(b) Canneries, cannery freight boats, and other cannery conveyances shall accept only fresh, clean, sound shrimp or oysters, the latter coming from unpolluted waters.

(c) After delivery of each load of shrimp or oysters to the cannery, decks and holds of each boat and the body of each other conveyance making such delivery shall be washed down with clean, unpolluted water and all debris shall be cleaned therefrom before such boat or other conveyance leaves the cannery premises.

(d) Before picking the shrimp or steaming or opening oysters by other means, they shall be washed with clean, unpolluted water and then passed over the inspection belt and culled to remove all shrimp or oysters that are filthy, decomposed, putrid, or otherwise unfit for food, and all extraneous material. Muddy oysters may be returned to the washer for washing.

(e) Offal from picking or shucking tables shall not be piled on the floor, but shall be placed in suitable containers for frequent removal, or shall be removed by flumes, conveyors, or chutes.

(f) Shrimp shall not be picked into cups but shall be picked into flumes which immediately remove the picked meats from the picking tables.

(g) Picked shrimp or shucked oysters being transported from one building to another before enclosure in the can or other immediate container shall be properly covered and protected against contamination.

(h) From the time of delivery to the cannery up to the time of final processing, shrimp or oysters shall be handled expeditiously and under such conditions as to prevent contamination or spoilage.

(i) The packer shall immediately destroy for food purposes all shrimp or oysters in his possession condemned by the inspector as filthy, decomposed, putrid, or otherwise unfit for food. Shrimp or oysters condemned on boat or unloading platform shall not be taken into the cannery.

(j) All portions of the establishment shall be adequately lighted to enable the inspector to perform his duties properly.

(k) All floors and other parts of the establishment, including unloading platforms and all fixtures, equipment, and utensils shall be cleaned as often as may be necessary to maintain them in sanitary condition.

(l) The packer shall require all employees handling shrimp or oysters to wash their hands after each absence from post of duty.

(m) The packer shall require all employees to observe proper habits of cleanliness, and shall not knowingly employ in or about the establishment any person afflicted with infectious or contagious disease.

(n) Offal, debris, or refuse from any source whatever, shall not be allowed to accumulate in or about the establishment.

(o) The delivery of steamed oysters to shucker by means of manually rolling, trundling, or wheelbarrowing such oysters on or above shucking tables will not be permitted.

(p) When the oysters are opened by steaming, the time and temperature of steaming shall not exceed the minimum time and temperature necessary to open the oysters and slip one eye.

(q) No shucked oysters shall be returned to the shucker after delivery to the weigher.

(r) The shucked oysters shall be washed by a suitable device and immediately drained. The time of washing shall not exceed the minimum time necessary for cleaning.

Code Marking

(a) Code marks shall be affixed to all cans and other immediate containers before they are placed in the processing retorts. Such marks shall show at least (1) the date of packing, (2) the establishment where packed, and (3) the size of the shrimp when such shrimp were graded for size and are not in containers through which they are clearly visible.

(b) Keys to all code marks shall be given to the inspector.

(c) Each lot shall be stored separately pending final inspection. For the purposes of these regulations all cans or other immediate containers bearing the same code mark shall be regarded as comprising a lot.

Processing

Shrimp. (a) The closure of the can or other immediate container and the time and temperature of processing the canned shrimp shall be adequate to prevent bacterial spoilage.

(b) The following processes shall be employed for the containers indicated:

Dry Pack				
Kind of Container	Liner	Size	Time at 240° F. Min.	Time at 250° F. Min.
Tin	One-piece	211 x 400	85	66
Tin	One-piece	307 x 208	85	66
Tin	One-piece	307 x 400	90	70
Tin	Two-piece	211 x 400	80	62
Tin	Two-piece	307 x 208	80	62
Tin	Two-piece	307 x 400	85	66
Tin	Three-piece or no liner	211 x 400	70	53
Tin	Three-piece or no liner	307 x 208	70	53
Tin	Three-piece or no liner	307 x 400	75	57
Tin (high vacuum)	Three-piece or no liner	307 x 208	55	. . .

Wet Pack			
Kind of Container	Size	Time at 240° F. Min.	Time at 250° F. Min.
Tin	102 x 300	. .	10
Tin	211 x 400	20	10
Tin	307 x 208	20	10
Tin	307 x 400	23	12
Tin	502 x 510	. .	13
Tin	603 x 700	. .	15
Glass	2 to 9 fl. oz.,	inc. 22	14

(c) For steam cook, blow-off vent shall be open during the coming-up period until the mercury thermometer registers at least 215° F. Bleeders shall emit steam during the entire processing period.

(d) The inspector shall identify each record on the thermometer chart with the code mark of the lot to which such record relates and the date of such record. The Administration shall keep such charts for at least five years, and upon request shall make them available to the packer.

(e) The packer shall keep for at least one year all shipping records covering shipments from each lot, and upon request shall furnish such records to any inspector of the Administration.

Oysters

The processing regulations are the same for oysters except that the following processes shall be the minimum employed for the containers indicated:

Size	Time at 240° F.	Time at 250° F.
211 x 400	23 minutes	13 minutes
307 x 409	27 minutes	13 minutes
301 x 411	25 minutes	13 minutes

Examination after Canning.

(a) Adequate samples shall be drawn by the inspector from each lot of canned shrimp or oysters and shall be examined to determine whether or not such canned shrimp or oysters conform to all requirements of the Federal Food, Drug and Cosmetic Act, amendments thereto, and regulations thereunder.

(b) The packer shall destroy for food purposes, under the immediate supervision of the inspector, all canned shrimp or oysters condemned by the inspector as not complying with the above processing requirements, or as filthy, decomposed, putrid, or otherwise unfit for food.

Labelling

(a) Labels on canned shrimp or oysters covered by a certificate of inspection shall bear the mark "Production Supervised by U.S. Food and Drug Administration." Such mark shall be plainly and conspicuously displayed in type of uniform size and style on a strongly contrasting uniform background; and shall appear on the principal panel or panels of the label so as to be easily observable in connection with the name of the article.

(b) Two proofs, or proof and one photostat thereof, or eight specimens of all labelling intended for use on inspected canned shrimp or oysters or on or within the cases therefor, shall be submitted to the Administration* for approval. If proofs or photostat and proof be submitted, eight specimens of the labelling shall be sent to the Administration after printing. The Administration is hereby authorized to approve labelling subject to the condition that such labelling shall be so used as to comply with the provisions of the Federal Food, Drug and Cosmetic Act, amendments thereto, and regulations thereunder. The Administration is also authorized hereby to revoke any such approval for cause. The Administration shall not approve labelling for canned shrimp or oysters intended for export.

(c) No commercial brand or brand name appearing on labelling approved as authorized under subsection (b), and no labelling simulating any such approved labelling, shall be used after such approval on canned shrimp or oysters other than that which has been handled, prepared, and

*Refers to the U.S. Food and Drug Administration in the subsequent text of these regulations.

packed in compliance with all provisions of these regulations; but this subsection shall not apply to any packer's labelling after termination of inspection as authorized under the subsequent section "Suspension, withdrawal, and termination of inspection service," or to any distributor's labelling after three months' written notice by the owner thereof to the Administration that the use of such labelling on inspected canned shrimp or oysters has been discontinued and will not be resumed.

Certificates of Inspection; Warehousing and Export Permits.

(a) After finding that the canned shrimp or oysters comprising any parcel (1) has been handled, prepared, and packed in compliance with all provisions of these regulations, (2) bears labelling approved as authorized, and (3) complies with all provisions of the Federal Food, Drug and Cosmetic Act, amendments thereto, and regulations thereunder, the inspector shall issue a certificate showing that such canned shrimp or oysters so comply. The certificate shall specify the code marks to which it applies, the quantity of the parcel so marked, the place where such parcel is stored, the size of the shrimp or oysters, the size and kind of containers, the type of pack, the commerical brand name on the labels, the quality grade of the shrimp or oysters if it be fancy, and the condition of the shrimp or oysters if broken. Such certificate shall become void if such labelling be removed, altered, obliterated, or replaced; but such canned shrimp or oysters may be relabeled under the supervision of an inspector and certified if the inspector finds that, after being relabeled, it complies with the requirements laid down by this subsection for the issuance of a certificate.

(b) Unless covered by certificate, canned shrimp or oysters shall be moved from an inspected establishment only for storage authorized under paragraph (c), or export authorized under paragraph (e), or for destruction.

(c) Application to move unlabeled canned shrimp or oysters from storage in a warehouse elsewhere than in the establishment where such shrimp or oysters were packed shall be on forms supplied by the Administration. The application shall give the name and location of the warehouse in which such canned shrimp or oysters are to be stored, and shall be accompanied by an agreement signed by the operator of shrimp or oysters so stored, and that conditions which will preserve the identity of each parcel of such canned shrimp or oysters shall be continuously maintained pending issuance of a certificate thereon or removal as authorized by subsection (d). If such application be approved and it appears to the inspector that the canned shrimp or oysters comprising any parcel (1) has been packed in compliance with these regulations, (2) is not slack filled, and (3) conforms, except for the absence of labelling, to all requirements of the Federal Food, Drug and Cosmetic Act, amendments thereto, and regulations thereunder, the inspector shall issue to the applicant, on his request, a warehousing permit covering such canned shrimp or oysters. Such permit shall specify the code marks to which it applies, the quantity of the parcel so marked, the places from and to which such parcel is to be moved, the size of the shrimp or oysters if broken. When any provision of the agreement is violated the Administration may revoke any permit issued pursuant to such agreement, and may also revoke its approval of the application for warehousing which accompanied such agreement.

(d) Unless certified by certificate, canned shrimp or oysters stored under the authority of subsection (c) shall be moved from the warehouse where stored only for restorage under such authority, or for return upon written permission of the inspector to the establishment where packed, or for export authorized under subsection (e), or for destruction.

(e) Section 801 (d) of the Federal Food, Drug and Cosmetic Act provides that a food intended for export shall not be deemed to be adulterated or misbranded under the act if it (1) accords to the specifications of the foreign purchases, (2) benot in conflict with the laws of the country to which it is intended for export, and (3) be labeled on the outside of the shipping package to show that it is intended for export. An application to export canned shrimp or oysters under the provisions of section 801 (d) of the Act shall be accompanied by the original or a verified copy of the specifications of the foreign purchases; if so required by the Administration, evidence showing that such canned shrimp or oysters are not in conflict with the laws of the country to which they are intended for export; and, if shipment of labeled canned shrimp or oysters be specified or directed, eight specimens of the labelling therefor. If canned shrimp or oysters prepared or packed according to such specifications be not in conflict with the laws of such country, the

Administration shall direct the inspector to issue to the applicant an export permit covering such canned shrimp or oysters comprising any parcel ordered by such purchaser under such specifica tions, when the inspector finds that such canned shrimp or oysters were packed in compliance with the requirements of these regulations regarding sanitary conditions and processing, are not filthy, decomposed, putrid, or otherwise unfit for food, accords to such specifications, and are labeled on the outside of the shipping package to show that they are intended for export. Such permit shall specify the code marks to which it applies and the quantity of the parcel so marked, and shall show that such canned shrimp or oysters were packed under sanitary conditions, are wholesome, and accords to such specifications. The applicant shall furnish to the inspector documentary evidence showing the exportation of all such canned shrimp or oysters. Canned shrimp or oysters intended for export under this subsection shall not be stored in any warehouse in the United States elsewhere than in the establishment where such canned shrimp or oysters were prepared or packed, except on written permission of the inspector, or of the chief of the Food and Drug Administration Station within whose territory such warehouse is located.

Suspension, Withdrawal; and Termination of Inspection Service

(a) The Administration may suspend and the Administrator may withdraw inspection service in any establishment (1) upon failure of the packer to comply with any provision of these regulations, or (2) upon the dissemination by the packer or any person in privity with him of any representation which is false or misleading in any particular regarding the application to any seafood of the inspection service provided by these regulations.

(b) When the inspection service is suspended in an establishment, as authorized by subsection (a), the Administration shall not lengthen the inspection period in such establishment to compensate for any of the time of suspension.

(c) After inspection service for a fiscal year is closed in an establishment, but before the resumption of packing therein during the next fiscal year, the packer may terminate inspection service under the regulations in this part by giving written notice of such termination to the Administration.

Regulations Governing the Handling of Shrimp for Freezing.

All establishments that are operated for the removal of heads or hulls from shrimp for the purpose of packing and freezing should be of such construction as will meet the sanitary requirements as set forth in the "Regulations for Inspection of Canned Shrimp." The operations for freezing shrimp are to some extent different from those of canning shrimp. In order to maintain clarity, the regulations for peeling and packing shrimp for freezing, in accordance with Sanitary Code of the State of Louisiana, are quoted:

The shrimp shall be emptied into a metal washing compartment and shall be carried from there by an inspection belt of sufficient length to allow adequate inspection for the removal of all shrimp which are in an unsatisfactory condition.

On leaving the inspection belt, shrimp shall be caught in metal baskets or containers for delivery to the tables where the heads or hulls are to be removed.

All edible portions left after the hulls or heads have been removed shall be promptly flumed to a metal skimmer for further inspection.

On leaving the skimmer, shrimp shall be placed in a metal tank containing ice water and crushed ice in sufficient quantity to maintain the temperature of the water at a temperature not to exceed 40° F.

Shrimp, with the heads removed that are to be transported to some other location for packing into unit containers for freezing, shall after thorough chilling in the crushed ice and water solution, be packed with a sufficient amount of ice to maintain the headless shrimp at or below a temperature of 40° F. until they be received at the packing plant.

When headless shrimp are packed in unit containers for freezing, either in the plant where the heads are removed or in the repacking plant, the packing shall be done as promptly as possible

on metal tables.

Where headless shrimp are packed in unit containers in the establishment where the heads are removed and are transported from there to a freezing plant the unit packages shall be packed promptly in crushed ice so that there is no delay in the cooling of the shrimp after being packed.

All containers in which headless or peeled shrimp are to be packed for freezing shall be dipped in a chlorine solution of not less than 50 ppm. immediately before being filled with shrimp.

All utensils used in the handling of headless or peeled shrimp, and all tables, skimmers, conveyors and other equipment, shall be treated each day by washing or rinsing in a chlorine solution of not less than 200 ppm. before the plant starts operating.

The ice water solution used for cooling the headless or peeled shrimp shall be drained off after each two hours' use, or less if used for less than that length of time; and the tank shall be washed and treated with a chlorine solution of not less than 200 ppm. after which the tank should be rinsed out with clear water.

All peeled shrimp for freezing shall be packed, in the containers in which they will be frozen, in the plant where the peeling operations are carried on.

The packing of headless or peeled shrimp in containers other than those bearing the permit number of the plant in which the shrimp are packed is prohibited.

All containers intended for use for packing shrimp for freezing shall be subject to seizure unless properly numbered with the permit number issued by the State Board of Health.

The peeling of shrimp, and packing in bulk containers for transportation to some other establishment for packing into unit containers in which the shrimp will be frozen, is prohibited. The packing of shrimp which have been peeled at some other establishment is also prohibited.

All cartons or containers in which headless or peeled shrimp are packed for freezing must be printed, stamped, embossed, or otherwise labeled with the number of the permit from the State Board of Health authorizing the packer to operate. This permit number must appear in addition to any other labeling which must be on the carton or other container.

The regulations also provide for the issuing, revoking, suspending, and reinstating of permits to operate.

Chapter XXIII

Some Simple Field Tests for Use in Food Control Work

The sanitarian becomes a more specialized individual as techniques and knowledge accumulate. But regardless of the high degree to which specialization develops, the sanitarian who becomes a specialist must first of all be a good general sanitarian. As food control work gets better and more intensified, the traffic of food samples to the laboratory for analysis becomes a flood with which the laboratories are scarcely able to cope. The solution of this problem is not only in developing more laboratory facilities but also in training the sanitarian to perform certain simple field tests which will allow him to be more selective in shipping samples to the laboratory. Such simple field tests will allow the sanitarian to screen the samples, where this is possible, and thereby reduce the number of samples to be shipped. It must be remembered that in cases where certain findings lead to legal procedures, such findings must be corroborated by tests performed in a qualified laboratory on samples correctly collected, shipped, identified and otherwise handled. Therefore, for legal purposes, field tests are not valid. The sanitarian must always remember that field tests are made only for the purpose of screening samples.

Detection of Spoilage of Shucked Oysters

Materials: Strips of No. 5264 Oxyphen test paper, a comparison color chart, a bottle of methyl red indicator solution of 0.02% in 50% alcohol.

Technique: Immerse a strip of test paper in the oyster liquor for about 5 seconds so as to cover all the colors on the paper. Shake off the superfluous liquor. Match the color of the wet indicator with the wet comparison colors for pH value.

Interpretation: Fresh shucked oysters have a pH between 6.0 and 7.0. A pH of 5.4 to 5.8 is regarded with suspicion while values below this range are indicative of decomposition.

If there be suspicion of oysters having been recently washed, several drops of methyl red indicator solution are placed directly on an oyster. The production of a persistent red color indicates spoilage.

Detection of Spoilage of Crab Meat

Materials: Vial of Nesslers reagent, a dropper, and a homeopathic vial.

Technique:

1. Transfer about 1/2 teaspoonful of crab meat to homeopathic vial.
2. Add 2 teaspoonsful of water and shake.
3. Add 0.5 ml. (one dropperful) of Nesslers reagent.

The Nesslers reagent is alkaline and must be kept in a fresh state. Storage in polyethylene or pyrex glass containers prolongs its life.

Interpretation: The immediate development of a deep yellow or brown color indicates spoilage of the meat. The discoloration is due to the ammonia developed from decomposed protein. The sanitarian is urged to develop his ability to detect spoilage by odor.

Detection of Cyanide in Metal Polish

Materials: Vial of sodium picrate test paper.

Technique:

1. Moisten a piece of sodium picrate test paper with water.
2. Suspend the moistened paper in container of suspected polish. Care is taken that the test paper does not contact the polish.

Interpretation: If paper turns orange and then brick red in 5 to 10 minutes, the concentration of cyanide compound exceeds 0.5%. The reaction is not wholly specific for cyanide, but it serves as a ready screening test in the field.

Sodium picrate test papers are prepared by dipping strips of filter paper into a 1% solution of picric acid, drying in air, then dipping into a 10% solution of sodium carbonate and drying in air. Preserve papers in a stoppered vial.

The Detection of Rodent Urine Stains

Materials: Test papers impregnated with urease enzyme and brom thymol blue indicator.

Technique:

1. Moisten a piece of impregnated test paper.
2. Press paper against the suspected spot for about 5 seconds.

Interpretation: The enzyme converts the urea of the rodent urine to ammonium carbonate which colors the indicator blue. The blue color develops gradually in about 1 or 2 minutes, and fades after about 15 minutes. The presence of interfering alkaline substances is established through the use of a control paper impregnated with the brom thymol blue indicator above. The test papers are stable for about 6 months. The test works best in the field for confirmation of stains revealed by ultraviolet light (See chapter on Rodent Control for the test with ultraviolet light.)

Fluoride-containing Insecticide Powders

Materials: Powdered citric acid, test paper.

Technique:

1. Mix a pinch of powdered citric acid and a pinch of suspected powder.
2. Moisten a strip of test paper with water and touch the acid powder mixture with the moistened paper.

Interpretation: The test depends on the fact that soluble fluorides decolorize zirconium lake of sodium alizarin sulfonate in the presence of acid. In the presence of a large amount of soluble fluoride, decolorization of the test paper will occur in about 5 seconds. A reaction time of about 5 minutes should be allowed for traces of fluoride. Phosphates and oxalates may yield false tests. Therefore positive findings should be confirmed in the laboratory.

The test paper is made as follows:

Dissolve 0.17 gram of alizarin sodium sulfonate in 100 ml. of water.
Dissolve 0.87 gram of crystallized zirconium nitrate in 100 ml. of water.
Mix two solutions with constant stirring.
Shake at intervals and let stand overnight.
Dilute 20 ml. of this stock solution to 100 ml. with water, and impregnate filter paper (Whatman No. 4).
The paper is air dried and then cut into 45 mm. x 7 mm. strips.

Detection of Sulphites in Meat Products

Materials: White paper, dropper bottle of 0.02% aqueous solution of malachite green, tooth-pick or small wooden spatula.

Technique:

1. Transfer 1/2 teaspoonful of suspected meat to a piece of white paper about 4 inches square.
2. Add 0.5 ml. (one dropperful) of malachite green solution to meat.
3. Thoroughly mix for about 1 to 2 minutes with a tooth pick or a small wooden spatula.

Interpretation: Meat containing sulfite will decolorize the dye and the meat will resume its bright red color. Normal meat will assume a darker blue-greenish appearance.

Malachite green dye certified by the Biological Stain Commission is used. The dye will be stable for several weeks, particularly if dispensed in polyethylene vials fitted with polyethylene dropper assembly and neoprene bulb.

Detection of Dye on Meat

Materials: 2 glass vials, bottle of 80% alcohol, 7 centimeter Whatman No. 4 filter paper.

Technique:

1. Transfer 1/2 to 1 teaspoonful of meat to a glass vial.
2. Add about 10 ml. of alcohol.
3. Shake mixture briefly.
4. Filter through a folded filter paper.
5. Collect filtrate in a second glass vial. Squeeze the filter paper to obtain sufficient filtrate.

Interpretation: The alcohol dissolves the dye if present. If the filtrate be pink or red, the presence of artificial color is indicated.

Detection of Nitrate in Meat Products, or Milk

Materials: A test tubes, distilled water, medicine dropper, diphenylamine solution (1 part diphenylamine to 99 parts sulfuric acid.)

Technique:

1. Place a half teaspoonful of hamburger or 5 ml. of milk in test tube.
2. Fill tube half full with distilled water, in case of meat, but add no water in testing milk.
3. Allow several drops of diphenylamine solution to run down the inside of the tube.

Interpretation: If nitrates be present, a blue color will appear at the level where the liquid and acid solution meet. The color does not last long and soon turns dark brown or black. Nitrates may be introduced into milk by water, if the milk has been watered.

Swab Test for Food Utensils

Materials: Vials with a plastic screw type of closure which hold a wooden applicator with cotton attached. Salt solution or broth is sterilized directly in the vials.

For technique and interpretation, see Chapter on Food Handling Sanitation.

Available Chlorine in Disinfectant Solution

Materials: Strips of starch-iodide paper (LaMotte or Coleman and Bell)

Technique:

1. Dip a strip of starch-iodide paper into disinfecting solution for about 3 seconds.

Interpretation: A deep blue color develops immediately in the presence of approximately 100 ppm. or more of available chlorine. A light blue color indicates less than this amount of chlorine. A color chart showing the characteristic colors developed in chlorine concentrations of 50, 100, and 200 ppm. can be obtained from the LaMotte Chemical Products Co., Towson, Baltimore, 4, Md.

Concentration of Quaternary Ammonium Compounds in Sanitizing Solutions

Test papers and color charts for estimating the concentration of quaternary ammonium compounds and directions for making tests can be obtained from the various manufacturers of these compounds.

Detection of Adequacy of Alkalinity in Wash Water

Materials: Glass flask, bottle of phenolphthalein.

Technique:

1. Place 100 millilitres of solution to be tested into a flask.
2. Add 5 drops of phenolphthalein indicator in flask and shake slightly.

Interpretation: If solution becomes deep pink, the alkalinity is adequate.

Detection of Cereal Adulterants in Ground Meat or Meat Products

Materials: Beaker (50 c.c.), bottle distilled water, filter paper, vial of tincture of iodine, medicine dropper.

Technique:

1. Place several ounces of ground meat in 50 c.c. beaker.
2. Add enough distilled water to thoroughly separate particles.
3. Stir up well.
4. Place some of the floating material on a filter paper.
5. Put several drops of tincture of iodine solution on particles and let stand a minute or two.

Interpretation: The appearance of a bluish or purplish color is an indication of the presence of a starchy material.

Detection of Cereal Adulteration in Coffee

Materials: Test tube, bottle of distilled water, vial of tincture of iodine, medicine dropper.

Technique:

1. Place 10 c.c. of sample in a test tube.
2. Add 10 c.c. or more of distilled water.
3. Stir up well.
4. Add 5 to 10 drops of tincture of iodine solution, drop by drop.

Interpretation: Any change in color of the liquid toward the bluish or purplish side is indication of presence of cereal.

Distinguishing Butter from Oleo

Materials: Tablespoon, dish or test tube; flame, stick or rod for stirring.

Technique:

1. Place some butter, the size of an almond, in a tablespoon or small dish, or test tube.
2. Heat spoon over flame till melted, then increase heat to a brisk boil. Stir continuously.

Interpretation: Oleo and renovated butter boil noisily, sputter more or less like a mixture of grease and water when boiling, and produce no foam, or very little. Renovated butter produces usually very little foam. Genuine butter boils usually with less noise and produces an abundance of foam. This is only a screening test. The refractometer reading gives more accurate result. Natural butter has a refractometer index at 40° C. ranging from 1.4531 to 1.4562, usually about 1.4553. Readings outside of this range indicate other types of fat.

Detection of Decomposed Meat

Materials: Test tube; forceps; reagent composed of one part concentrated hydrochloric acid, one part ether, three parts absolute alcohol.

Technique:

1. Place 2.0 c.c. of the reagent in a clean test tube and shake.
2. Lower small piece of meat to be tested into test tube with a forceps to within 1/2 inch of surface of reagent. The meat must be defrosted and brought to room temperature before subjecting it to this test.

Interpretation: If ammonia be present, white ammonia chloride fumes will appear around specimen. This test should not be a substitute for the simple odor and visual examination of meat.

Detection of Formaldehyde or Formalin in Milk

Materials: Test tube, vial of 1% ferric chloride solution, vial of commercial sulfuric acid, medicine dropper.

Technique:

1. Place 10 ml. of milk in test tube.
2. Add 3 or 4 drops ferric chloride.
3. Add 1 or 2 ml. of sulfuric acid by letting it run down the side of the tube in such a way that it does not mix with the milk but forms a layer at the top.

Interpretation: At the line where the acid meets the milk a deep lavender color will form if formaldehyde be present. This test will be unreliable if the formaldehyde has been in the milk longer than 36 to 48 hours.

Detection of Peroxide in Milk.

Materials: Test tube, vial of paraphenylendiamine-hydrochloride.

Technique:

1. Place 10 ml. of milk in test tube.
2. Add small pinch of paraphenylendiamine-hydrochloride such as might be held on the point of a knife blade.
3. Shake powder well with milk.

Interpretation: If peroxides be present, a deep blue color will result. If no peroxide be present, no change will occur or else a slightly dark color. This test is uncertain if the milk has been heated to 165° F. or higher and therefore has destroyed the peroxidase enzyme. The latter fact can be used for testing whether milk has been heated to a high temperature or boiled.

Detection of Gelatin in Cream.

Materials: 2 test tubes, vial of acid mercuric nitrate solution (mercury dissolved in twice its weight of nitric acid and then diluted 25 times the resulting volume with water), filter paper, funnel, vial of saturated solution of picric acid.

Technique:

1. Place 10 ml. of cream in test tube.
2. Add 10 ml. of a solution of acid mercuric nitrate.
3. Shake the tube thoroughly 3 or 4 times at intervals of 3 to 5 minutes.
4. Filter.
5. Add to filtrate an equal amount of saturated solution of picric acid.

Interpretation: If gelatin be present, a cloudy precipitate will result. If much gelatin be present the precipitate will be yellow. If no gelatin be present the solution will remain clear.

Detection of Coloring Matter in Milk, Cream, or Butter

Materials: 2 test tubes, vial of ether, vial of normal hydrochloric acid.

Technique:

1. Place 10 ml. of milk, cream, or small quantities of butter in each of 2 test tubes.
2. Add an equal volume of ether to one test tube, and an equal volume of normal hydrochloric acid to the other.
3. Shake each well several times in order to dissolve the fat.
4. Allow the tubes to stand for a few minutes.

Interpretation: If a vegetable color such as "annatto" be present, the solution of ether and fat in the first tube will be yellow. If a coal-tar color be present the second tube will turn pink.

Detection of Sodium Carbonate in Milk or Cream

Materials: Test tube, vial of alcohol, vial of 1% solution of rosolic acid.

Technique:

1. Place 10 ml. of milk or cream in test tube.
2. Add an equal volume of alcohol.
3. Shake thoroughly.
4. Add 10 drops of rosolic acid.

Interpretation: If carbonates or bicarbonates be present a rose red color will appear. If no carbonates or bicarbonates be present, the solution will turn brownish yellow.

Detection of Borax or Boric Acid in Milk or Cream

Materials: Vial of concentrated hydrochloric acid, beaker, vial of turmeric paper, vial of sodium hydroxide.

Technique:

1. Place 30 ml. of milk or cream in beaker.
2. Acidify with 2 ml. hydrochloric acid.
3. Immerse a strip of turmeric paper in acidified liquid, and allow it to dry spontaneously.

Interpretation: If borax or boric acid be present, the paper will acquire a red color. If a drop of sodium hydroxide be placed on the paper the color will change to olive green.

Babcock Test: Determination of Butter Fat in Milk

Materials: Standard Babcock milk-test bottle, pipette, acid measure, centrifuge, dividers or calipers, water bath for test bottles.

Technique:

1. Measure 17.6 c.c. of milk in pipette and transfer to test bottle.
2. Measure 17.5 c.c. of commercial sulphuric acid and transfer slowly to test bottle while using a gentle rotary motion of test bottle during the mixing. Mixing is complete when the curds are completely dissolved and the entire mass becomes dark brown. (Sulphuric acid dissolves protein but not the fat.)
3. Centrifuge test bottle for 5 minutes to separate fat from acid solution.
4. Add hot water (130^{O} F.) to bring content in bottle up to the neck (heat and water aid in separating fat from acid solution.) Centrifuge test bottle for 2 minutes.
5. Add more hot water so that the fat column is well above the zero mark on the graduated scale. Centrifuge again for 1 minute.
6. The length of the fat column is measured by dividers (calipers). The spread of the dividers is maintained while one point is placed on the zero of the graduated scale with the other point, falling on the graduated scale.

Interpretation: The spread of the calipers measuring the length of the fat column will directly indicate the percent of the fat in the milk.

Mann's Test: Determination of % Acidity in Milk

Materials: White cup, burette.

Technique:

1. Mix the sample of milk thoroughly, then transfer 17.6 c.c. into a white cup.
2. Add 3 or 4 drops of phenolphthalein.
3. Fill the burette with one tenth normal (n/10) sodium hydroxide and record the reading. Let the sodium hydroxide run into the milk, drop by drop, stirring constantly. When pink color appears, discontinue sodium hydroxide.

Interpretation: Read in tenths (on graduated scale of burette) the amount of alkali used, and divide by two. Move the decimal point one place to the left and the answer will be the correct amount of acid in the milk.

Lactometer Test: Determination of % Solids-not-fat, Total Solids and Adulteration of Milk

Materials: Lactometer, glass cylinder.

Technique:

1. Mix sample thoroughly and have the temperature about 60^{O} F. Pour enough of the mixed sample into the cylinder to float the lactometer. The cylinder should be about three-fourths full.
2. Insert the lactometer into the cylinder and see that it floats freely.
3. Take reading as soon as the lactometer comes to rest. Read on a level with the surface and not where the milk strikes the side of the stem as there will be a slight rise in the

surface at this point. Record the lactometer reading and the temperature of the milk. By comparing the lactometer reading to chart, the amount of total solids will be estimated. Subtracting the percent butter fat (as found by Babcock Test) from total solids, the percent solids-not-fat is found.

4. Detecting Adulterated Milk using the Quevenne Lactomater.

The lactometer is an instrument used to assist in detecting whether milk has been watered, skimmed, or both. The instrument is standardized to such a weight that when placed in normal milk it will sink to the mark 32 (taking reading at top of meniscus), which means that the milk has a specific gravity of 1.032. Similarly, if the milk has a specific gravity of 1.015 or 1.040 the lactometer will sink to the marks 15 or 40, respectively. From this it will be seen that the method of obtaining the specific gravity of milk from the lactometer reading, is to divide by 1,000 and add 1.0. Conversely, the lactometer reading can be determined from the specific gravity of milk by subtracting 1 and multiplying by 1,000. Specific gravity of normal milk is from 1.029 to 1.034.

5. Correcting the Lactometer Reading.

All lactometers are standardized for use at a certain temperature, i.e., 60 degrees F. For each degree above 60 degrees F. add .1 to the lactometer reading. Example: If lactometer reading be 32 at 66 degrees F. then the corrected reading is 32.6, and the specific gravity of the milk is 1.0326. For each degree below 60 degrees F. subtract .1 from the lactometer reading.

6. Calculating the Percent of Milk-Solids-not-Fat (M.S.N.F.) and Total Milk Solids (T.M.S.)

To find the milk solids in milk, both the lactometer reading and the results of the Babcock Test are required. These figures are applied to the following formula:

$$1/4\,L + (0.2x\%\ \text{fat}) = \text{M.S.N.F.}$$

L is the corrected lactometer reading. Example, if the lactometer reading be 26.9 at 55° F. and the Babcock Test be 4.0% fat, then M.S.N.F. and T.M.S. are found as follows:

Corrected L =	26.4
1/4 of 26.4 =	6.6
0.2 x 4.0 =	0.8
6.6 + 0.8 =	7.4% M.S.N.F.
7.4 + 4.0 =	11.4% T.M.S.

To find the percentage of water added use the following formula:

$$\frac{\%\ \text{M.S.N.F. (State Standard)} - \%\ \text{M.S.N.F. (found by test)}}{\%\ \text{M.S.N.F. (State Standard)}} \times 100 = \%\ \text{water added}$$

Interpretation: If 8.5% M.S.N.F. be the state standard, then

$$\frac{8.5 - 7.4}{8.5} \times 100 = \frac{1.1}{8.5} \times 100 = \frac{110}{8.5} = 13\%\ \text{water added}$$

7. The New York State Board of Health Lactometer: This type of lactometer is coming more and more into use. The readings of this lactometer are different from that of the Quevenne. One degree of the New York Board of Health lactometer is equivalent to 0.29 degree of the Quevenne. Therefore in changing, for example, 112 N.Y. Board of Health degrees to Quevenne degrees, multiply 112 x 0.29 and the answer will be 32.48 Quevenne degrees. In changing Quevenne degrees to N.Y. Board of Health degrees divide the Quevenne degrees by 0.29.

Rupp Test: Tentative Test for Detection of Hypochlorites and Chloramines in Milk.

Materials: Test tube, glass rod, water bath, potassium iodide solution (7 gm. KI to 100 ml. water), hydrochloric acid (33.3% solution).

Technique:

1. To 5 ml. of milk in medium sized test tube add 1.5 ml. of freshly prepared potassium

iodide solution; mix thoroughly by shaking, and observe color of milk.

2. If unaltered, add 4 ml. of the 33 1/3 % hydrochloric acid; mix thoroughly by means of glass rod flattened at one end, and note color of curd.

3. Next, place tube in large water bath, previously heated to 85° C., and allow to remain 10 min. (during this interval curd will rise to surface); then cool rapidly by placing in cold water. Note color of curd and liquid.

4. Then add 0.5 - 1 ml. of a 1% starch solution to liquid below curd; note color.

Interpretation: The color resulting from the above 4 procedures are compared to the data in Table 77 for the amount of chlorine present in sample.

Table 77. Reactions with the Various Tests Indicating Presence of Chlorine

Concentration of Available Chlorine	1:1,000	1:2,000	1:5,000	1:10,000	1:25,000	1:50,000
ppm.	1000	500	200	100	40	20
Test 1	Yellowish Brown	Deep Yellow	Pale, Yellow, fades	- - -	- - -	- - -
Test 2	Yellowish Brown	Deep Yellow	Light Yellow	- - -	- - -	- - -
Test 3	Yellowish Brown	Deep Yellow	Yellow	Yellow	Pale Yellow	Yellowish
Test 4	Blue Purple	Blue Purple	Blue Purple	Dark Red Purple	Red Purple	Pale Red Purple

Boiling Test for Milk Quality

A small quantity of milk is boiled to observe whether it coagulates.

Interpretation: Milk containing about 0.26% acid will coagulate when boiled. The increased acid is the result of poor quality caused from poor technique in production. Such milk therefore should not be used for market milk purposes. Such milk may or may not coagulate when pasteurized. Since colostrum milk contains large quantities of albumin, it will thicken on boiling.

The Curd Test

Materials: Sterile test tubes, sterile pipettes, weak litmus solution, water bath.

Technique:

1. Place into each test tube 10 ml. of milk with a sterile pipette.
2. Add to each tube 4 or 5 drops of weak litmus solution, and mix thoroughly. Number each tube.
3. Tubes are placed in water bath at a temperature of 37° C. for 6 to 12 hours.
4. Observe the contents in each tube from time to time for rapidity of acid formation, curdling, and gas formation.

Interpretation: The quality of the milk is poor and the bacterial content is great if within 6 to 12 hours:

1. The acid formation is great enough to turn the blue litmus red.
2. The milk curdles.
3. Gas pockets are observed in the curd.
4. Bad odors develop.

If this test be performed on each batch of milk brought to the station, the dairies producing the poorer quality milk can be detected and the milk separated from the general supply until corrections are made in the particular dairies.

The Alizarol Test for Acid in Milk

Materials: Alcohol (78%) with alizarin powder added (0. 4 grams to each liter of alcohol), test tube.

Technique: Mix 2 ml. of milk and 2 ml. of alcohol with indicator in a test tube.

Interpretation: Fresh milk with 0. 16% acid will give a lilac red color, milk with 0. 25% acid will give a brown color, and milk with 0. 36% acid will give a yellow color. With this test the character of the coagulation of the casein may also be noted.

The Brom Thymol Blue Test for Mastitis.

Materials: Brom thymol blue solution (2 grams of brom thymol blue powder to each 350 ml. of alcohol), test tube.

Technique:

1. Place 3 ml. of suspected milk in a test tube.
2. Add 4 drops of brom thymol blue solution and shake well.

Interpretation: Normal milk will give a greenish yellow color, but infected milk will give greenish blue color. The intensity of the color will depend upon the degree of the mastitis. Badly infected milk will give a blue color. Milk with abnormal acid content will give a yellow color.

To Determine % Moisture in Butter

Materials: Small aluminum dish of known weight, scale, flame.

Technique:

1. Place 10 grams of butter in dish.
2. Weigh dish and butter.
3. Heat sample till water has evaporated.
4. Cool and re-weigh.

Calculation: Subtract weight of butter and dish after heating from the weight before heating. The difference is equal to the loss of moisture from the butter. The loss of moisture multiplied by 10 will give the % of moisture lost from the butter.

To Determine the Adequacy of Fat Content of Butter

By Federal law, butter must contain at least 80% milk fat. The usual salt content of butter is 2 to 3%; the usual curd content is about 1%; therefore if no more than 16% moisture be allowed, the fat content will be just about 80%. On the basis of the foregoing reasoning, the adequacy of the fat content of butter may be approximately deduced if the moisture content be first determined.

Other Tests. In chapter on Market Milk Control will also be found a field test for "percent of alkali and caustic, " and a number of other field test for determining the efficiency of pasteurization equipment. In the chapter on Bacteriology of Milk there is described a field phosphatase test for milk.

Chapter XXIV

Instruction Program for Food Handlers

As public health progresses it becomes evident that disease control measures, essentially regulatory in nature, are not sufficient in the complicated social organization of our times. To achieve a high measure of disease control in the food industry the cooperation of owners and workers is essential. The enforcement of sanitary regulations is but one phase of a program of good sanitation. Another phase is education. Enlightened workers and their employers along with an enlightened public tend to insure the highest level of disease prevention. Regulatory procedures to a certain extent are educational in nature, and education procedures tend to negate the need for the enforcement of regulations. This is especially true when efforts are made to enlist the enlightened participation of management and its workers. In the control of diseases spread by food, it has become apparent that regulatory annual physical examination of food handlers has contributed little towards the control of disease spread through food. Discretionary application of the physical examination may be of some use in some phases of control. Frequent physical examinations are neither feasible nor practical under present circumstances.

The food handlers must be taught to understand the rationale of the regulations and their own responsibility in the social scheme toward disease control. This can be accomplished most effectively where management and employees can be induced to recognize their responsibilities to the public and where management can be made to understand that good working conditions will engender a feeling of respect and good will among the employees to their work so that they will carry out the regulations as an expression of their own responsibility and not as compliance under the duress of enforcement. Thus, the need for instruction and training of food handlers came into being. In 1938 the Texas State Health Department and soon thereafter, the health department of Flint, Michigan developed courses for instructing food handlers which quickly spread their influence over the country. In 1946, the U. S. P. H. S. pamphlet "Guide to Safe Food Service" sumarized the experiences up to that time in organizing and conducting classes for food handlers.

The education of food handlers is attended by various problems in many instances. Restaurant employees are generally not stably situated, since the wages are low and conditions of work not very desirable. It is difficult under these conditions to evoke a sense of responsibility from the worker in regard to his work. Under such circumstances the training of the employee will be as effective generally, as he is satisfied with his job; and his sense of responsibility will likewise be in a similar proportion. It therefore becomes necessary to place the bulk of responsibility on the owner or operator of the establishment. Under such circumstances, it is necessary to train the operator or owner as well as the employees. An owner or operator will find it more difficult to disclaim responsibility for a violation when he knows the technique of correct food handling hygiene. But how can we guarantee that an operator or owner knows the correct technique. One obvious way is to bind the issuance of a permit to operate a food handling establishment together with the passing of an examination on food handling technique as prescribed by the local sanitary regulations. This can further be extended by requiring that the annual renewal of the permit be conditioned by attending a class on food handling sanitation. Mandatory attendance of employees at such classes may or may not be necessary. Such a provision was added to the food ordinance at Flint, Michigan in 1939. It is, therefore, obvious that management should be the responsible target of the food handling education program. It is legally, indeed, management's responsibility to maintain a clean and sanitary establishment and to train its own personnel in the hygiene of handling food.

It is generally agreed that the program for food handlers' instruction should include the following subject matter.

1. A presentation of the nature of germs with emphasis on those which cause epidemic diseases.
2. A presentation of the mode of spread of the common communicable diseases, especially those associated with food, including the role of insects and rodents.
3. A lesson in the sanitary details of preparation, serving, storage, refrigeration and waste disposal of foods.
4. A demonstration in disinfection and sanitization of utensils and equipment and the details of good housekeeping.

5. A course in personal hygiene and esthetic practices in the preparation and serving of food.

6. The use of the inspection sheet as the focal point of instruction, emphasizing those items of hygiene found to have been most frequently violated.

Another subject that is becoming popular in food handling instruction pertains to lessons for operators, managers and owners relating to the economics of buying, storing, and preparing of food and the buying and caring for equipment and supplies.

The length of the entire course and the intervals between each class or lecture will vary with the circumstances of the locality. Where only three lessons are feasible for a course, the subject matter above in items 1 and 2 may be combined, and items 3 and 5 may be combined. Where greater detail is desired, item 2 may be divided so that the roles of insects and rodent vectors are presented as separate lessons. In the case where the course is given to operators, owners, and managers, enough time should be given for an explanation of the legal sanitary provisions required, the public health reason for the requirements, and what is acceptable as satisfactory compliance.

A similar type course may be developed for dairymen. But in this case the legal sanitary provisions must be included in the course for detailed discussion.

Every opportunity should be taken for giving specialized courses in food handling hygiene to specialized groups such as lunch room workers, hospital personnel, and nursing home personnel.

The education of the public must be a continual program in order that the consumer keep effective pressure on food handling establishments to maintain hygienic conditions. An enlightened public can make the work of the sanitarian much simpler.

Since the inception of programs for the education of food handlers, changes in methodology and philosophy have occurred. A better understanding of the background of the restaurant worker based upon surveys conducted by health departments and the National Sanitation Foundation has resulted in wholesome changes. We have learned that people who have been out of school for many years or who have had but little formal education respond poorly to formal didactic lectures conducted in classroom fashion. Workers who have been on their feet for hours are poor recipients for the barrage of scientific information blasted at their unwilling ears. Failure to indoctrinate the food handler in the importance of this role often results in apathetic or even belligerent audiences. Repeated exposures to the fast tempo of Hollywood produced movies make it difficult for the food school participants to adjust to the slower non-story type of film commonly used. The workers who have been forced to attend but whose ears still burn with the aspersions that they have heard management cast at the health authorities are indeed poor subjects for learning. Huge theatres or meeting places packed with sweltering uncomfortable food handlers result in impressive attendance statistics but in few changes in the food handling habits of food handlers.

Whereas changes have occurred in the philosophy underlying the conduct of food schools, the basic philosophy of the operator in regard to his business has remained static. Like all business people, his primary objective is to make money. Utilizing all the short cuts and devices permissable by the letter of the law, the operator, unless thoroughly indoctrinated as to the importance of good sanitation, will most reluctantly cooperate in the program of instruction. The unscrupulous operator caring little for the letter of the law and less for its spirit has in many instances failed to cooperate. A recognition by sanitarians of the importance of dovetailing the principles of good sanitation with those of good business has stimulated greater cognizance of the importance of the educational approach. Consumer education, by means of programs for housewives and others has also produced its share of good.

Programs conducted by itinerant sanitarians or health educators came in for their share of criticism. Lack in understanding the precise rationale for organizing instruction programs and therefore vagueness in setting definite objectives often resulted in disappointments as to the extent of achievement. The realization has come that instructional courses were not a

panacea to correct all ills. A three or ten hour course could not accomplish what sanitarians had failed to achieve in years of diligent work. Lifetime habits of food handlers were not changed overnight. The diversified backgrounds of the participants made it difficult to set up courses which were not too elementary for some and not too advanced for others. In some instances instructional courses were conducted annually because of the additional points to be earned on food handling establishment survey ratings. When yearly courses were conducted, even though the turnover of help was high, many workers were exposed to a repetition of a program that they had heard previously. Health departments operating under limited budgets were forced to turn to other agencies for assistance. A questionnaire which was sent to all state health departments revealed that the Departments of Education through their vocational education or distributive education division had been the agency most cooperative. State and local restaurant associations have also assisted. The National Sanitation Foundation and The Paper Cup Institute have also made contributions towards the advancement of the program.

The skilled sanitarian of today, in setting up a program, should be able to profit from the lessons learned by the pioneers of this comparatively new aspect of the control of diseases that are inherently potential in the conduct of the food industry. In developing his educational program for the sanitary handling of food, he should consider:

1. Definite objectives --just what he hopes to accomplish by his program. He has learned that a practical objective is the stimulation of the pride of the worker by making him aware of the importance of his role to the community in the prevention of disease.
2. To what extent it is feasible for health authorities to assume the entire responsibility for the training of restaurant personnel.
3. To what extent it is the responsibility of management to train its own workers.
4. How much emphasis should be placed upon instructional programs for owners. In this connection current trends indicate the increasing acceptance of this approach.
5. The incorporation of items highlighting good sanitation as a means to increase profits.
6. The importance of consumer education as a vital adjunct to the improvement of restaurant sanitation.
7. The necessity of frequent repetition of the instructional programs, so as to take care of changes in personnel and to have others acquire beneficial habits by repeated exposure.
8. The relative importance of the establishments that serve many people in comparison to smaller establishments.
9. The difficulties involved in practicing good sanitary procedures under unfavorable conditions; i.e., kitchens built to serve 100 customers which are now serving five times as many.
10. The advantages of inaugurating a system of self-inspection on either a voluntary or compulsory basis.
11. The establishment of a written or oral examination as a prerequisite for obtaining a permit to operate.
12. The advantage of working with restaurant associations and labor unions to achieve results mutually advantageous to all concerned.
13. Utilizing different approaches and techniques depending on local conditions.
14. Whether it is necessary for the sanitarian to call for outside aid or whether he and his colleagues have the knowledge and the training to assume the entire responsibility of developing and presenting the food handler instructional program.
15. The establishment of criteria to evaluate the effectiveness of the instructional program.
16. How the producer of films could be encouraged to produce dramatic types of films relating to food handling education in order that the trainees will not fall asleep during showings.
17. How to develop an organized program for getting motion picture and TV producers to include sanitation tips in their productions such as having customers request "clean glasses" or "pasteurized milk" in appropriate settings. And also to protest to these producers of films and TV when unsanitary situations are unwittingly shown on the screen as normal and acceptable.

In developing the content of his program, the factual and scientific materials contained in this book can serve as the reservoir of information for the sanitarian. In deciding as to

techniques and procedures, the sanitarian should consider the methodology of the public health educator, the entertainment, advertisement and mass communications industries, and the public relations services. The use of propaganda is basic to success in this program. Propaganda is a concerted movement for propagating particular doctrines and principles. No better use of propaganda can be conceived than for bettering the health of the community.

Chapter XXV

Refuse Disposal

Refuse control is the job of both the sanitarian and the engineer. The planning of a large scale collection system, disposal by grinding, permanent incineration plants, cooking plants, and sanitary fills are basically engineering problems. The control measures for hog feeding of garbage, hog farm sanitation, various temporary small scale measures of garbage and refuse disposal, small town operations (in consultation with engineers if possible), nuisance, and vermin control are the province of the sanitarian. The sanitarian should know as much as possible about the principles of large scale refuse control in order to have the basic knowledge to improvise in case of emergency or in case of other situations requiring knowledge of temporary refuse control practice, and also to serve as assistant to engineers in large scale projects.

Definitions

Refuse - all putrescible and nonputrescible solid wastes, except body wastes. Refuse includes garbage, rubbish, ashes, street cleanings, dead animals, abandoned automobiles, and solid market and industrial wastes.

Garbage - the putrescible animal and vegetable wastes resulting from the handling, preparation, and consumption of foods.

Swill - includes that particular garbage which is wholly or nearly so, edible and useable as a food and having food value for animals or fowl, accumulating from animal, vegetable or other matter wasted from clubs, hospitals, hotels, restaurants, and public eating places.

Rubbish - all nonputrescible solid wastes, except ashes. Rubbish consists of both combustible and noncombustible material, such as paper, cardboard, tin cans, yard clippings, wood, glass, bedding, crockery, metals, and similar materials.

Waste Matter - includes waste material composed of soil, earth, sand, clay, gravel, loam, stone, bricks, plaster, crockery, glass, glassware, ashes, cinders, shell, metals, and all other noncombustible material which has been or is discarded or is to be discarded.

Ashes - the residue from the burning of wood, coal, coke, or other solid combustible materials.

Composition

An analysis of the seasonal variation of the composition of refuse collected in urban areas of temperate U. S. would show an inverse relation between food refuse and ashes. These two items are the most variable. In New York, in the months from November through March, the refuse collected is made up of from 5 to 10% of food refuse, and 50 to 80% of ashes; in the months of May through August, the percent of food refuse rises to 25-45% and the ashes falls to 7-30%. Other classes of refuse vary much less.

Average garbage contains from 65 to 80% of water. A study in Lansing, Michigan showed that 93% of garbage is volatile and that 20% of the dry base is grease. About 85% of the dry matter is combustible. About 50% of kitchen waste is made up of waste edible food, and 50% is waste nonedible food. The quantity of garbage produced, exclusive of tin cans, will usually vary from several ounces to a pound or two per capita per day. Variations in quantity are due to the conditions under which the food is prepared, that is, the size of the kitchens, the economic group concerned, the facilities for and methods of preparing the food, the character and palatability of the food, the training of the kitchen personnel, and the measures taken to guard against wastage.

The more common types of dry waste usually included in municipal refuse are shown in Table 1. The quantities and unit weights indicated for each have been assembled from various sources. They are cited to emphasize the wide variation in quantity and costs which are experienced, and the need for each city to analyze the characteristics of its own refuse before attempting to adopt practices which have proved satisfactory elsewhere. The costs are given as reported and do not in all cases include the same individual items of expense. The methods used for estimating the amounts of refuse collected vary widely in each city and render it difficult to compute comparable unit costs. Costs are for the 1950 period.

Collection

Garbage, rubbish, and ashes should be stored in separate containers regardless of the method selected for collection and disposal. This will be found advisable in cities collecting all materials in the same vehicle, and in those making separate collections.

In England, an intensive campaign to salvage metals and paper from household waste has resulted in the requirement that individuals separate paper, rags, metals, and other materials before placing them for collection.

Costs of collection will be found ordinarily to exceed the costs of disposal and thorough consideration of this fact is essential to a proper analysis of the problem. Cities which collect all classes of refuse together commonly report a substantially lower collection cost per ton or per capita than those cities which collect rubbish and garbage separately. One 12 cubic yard packer type truck is needed for each 5,000 to 8,000 population, plus one open body truck for large boxes, trees, brush, etc.

Combined collection is not feasible with all disposal methods. For instance, garbage used for hog feeding must be segregated from other waste materials. When the increased costs of separate collection are considered, however, it becomes difficult to justify hog feeding or other utilization of garbage by itself from an economic standpoint.

There are many cities which do not attempt to collect all forms of refuse but restrict their activities to garbage alone, or to rubbish alone, allowing private scavengers to collect garbage in the latter case. However, present tendencies in municipal cleansing are for the city to provide all refuse collection necessary to the maintenance of proper sanitary standards at a fixed charge rather than to rely upon individuals to maintain their neighborhood in a satisfactory condition. Fixed costs to the city remain about the same whether all service required is furnished or whether the householder is permitted to decide what portion of the service he desires to pay for and utilize. Collection either by contract or by municipal forces are satisfactory where competent municipal supervision is provided.

Regardless of the collection practice followed, it is recommended that each household be equipped with a hot dipped galvanized steel can for garbage. Substitute materials do not appear sufficiently resistant to garbage acids and abuse to show satisfactory wearing qualities. A

capacity of 7 to 10 gallons appears adequate for the average family. The can should have a tight-fitting, locking-type of cover, and a slightly recessed bottom. For the capacities noted, 26 to 30 gage metal has proved acceptable. Cans should be cleansed with hot soapy water or hot water and lye after each emptying. If lye be used the can should be thoroughly rinsed, especially if garbage be used for hog feeding.

Table 1. Common Types of Dry Wastes in Municipal Refuse

Types of Refuse	Pounds per capita per day				Weight per cubic yard		Collection cost per ton in dollars		Collection cost per cubic yard, in dollars	
	Summer		Winter							
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Garbage: Food Waste from kitchen and market	0.30	2.3	0.2	1.2	800	1,500	1.00	8.92	0.61	1.37
Rubbish: Paper wood, bedding, metal, glass, dirt, etc.	0.60	1.8	0.4	1.1	100	700	1.00	14.00	- - -	- - -
Ashes	0.12	0.2	1.9	3.2	1,500	1,400	- - -	- - -	- - -	- --
Street refuse: Sweepings, dirt, leaves, etc.	0.5	1.5	0.5	2.0	800	1,400	- - -	- - -	- - -	- - -
Garbage and combustible rubbish combined	0.7	3.9	0.3	1.8	200	800	1.00	8.83	0.62	1.22
Ashes and noncombustible rubbish combined	0.1	1.1	0.60	5.0	750	1,165	0.67	2.52	0.49	0.93
All refuse combined	1.2	3.4	2.1	5.5	500	1,000	1.00	5.00	0.25	1.53

Provision of a small, adequately drained wood or concrete platform for cans at each home will increase the wearing qualities of the cans considerably. The construction of such platforms should be designed to avoid the creation of rat harborages. If wooden platforms be used they should be about 1 foot high to facilitate cleaning under them. The top of the platform should be constructed so it will not accumulate organic matter. The platform should be scrubbed often and the ground around it kept clean and oiled to prevent fly breeding. Garbage should be well drained before it is placed in the cans. Many communities require that garbage be drained, wrapped, and tied before being placed in containers. This practice has been found valuable in increasing container life and ease of collection, and may permit the use of other than steel containers. It is not feasible, however, in cities using hog feeding or reduction as a method of disposal. Rubbish may be stored in wooden barrels, boxes, or burlap bags.

Some cities require that householders place refuse at the street curb on collection days while others permit collectors to enter back yards and basements. The former method may be expected to show considerable economy in collection costs.

Collection vehicles should be constructed of metal and be equipped with covers or tarpaulins

to prevent spillage, odors, and other nuisance complaints. Reports indicate that trucks using a three-man crew have provided a most satisfactory service in many cities.

In estimating requirements, it can be figured that 250 to 400 collections can be made per day per truck, that a 12 cubic yard packer type truck can carry 5 to 7 tons of refuse, and that each residence will average 50 to 60 pounds of refuse (both garbage and rubbish) per week, or one ton of refuse per average residence per year, or an average of 2 pounds of refuse per person per day (including commercial.)

In residential districts, semi-weekly collection of garbage should be regarded as the minimum desirable. Daily collections should be provided in commercial areas. More frequent collections may be required in summer. The attempts to reduce the frequency of collection may result in overloading of individual garbage storage facilities and cause a serious health hazard. Less frequent collections also tend to render the emptying of containers more difficult and can reduce the efficiency of collection. Arrangements should be made promptly to extend collection service to areas hitherto not served where a rapid population expansion results in unusual accumulations of refuse.

It is important that municipal ordinances be provided to enforce practices decided upon following consideration of some of the questions outlined above.

The distance which refuse must be hauled and, more particularly, the time required for hauling, are of prime importance in the cost of collection. The topography of the district, population distribution, and the lay-out of streets and alleys will all affect the type of vehicles used and the collection routes chosen.

Disposal Methods

A thorough consideration of collection problems will emphasize the advantage of selecting a method of disposal which can be located close to centers of population. Alternate costs of using one or several points of disposal should also be considered. Insofar as possible, collection vehicles should be diverted from main traffic routes and operated during off-peak hours of traffic flow. Among the more common methods for the ultimate disposal of one or more types of refuse are the following:

Hog Feeding. Surveys by the United States Public Service indicate that over 50 percent of the cities questioned disposed of all or a portion of their garbage by hog feeding. The surveys also revealed a surprisingly high incidence of trichinosis among hogs which were fed uncooked garbage. Consumption of insufficiently cooked pork from such hogs is believed to be the chief source of human trichinosis, a serious disease resulting in gastro-intestinal disturbances, remittent fever, and muscular pain. Although frequently diagnosed incorrectly, trichinosis is reported most frequently from areas where large number of garbage-fed hogs are raised. There are many diseases of swine which are transmitted among the swine population by garbage. They include hog cholera, vesicular exanthema, foot-and-mouth disease, salmonellosis, tuberculosis, swine erysipeles, anthrax brucellosis, and trichinosis. Except for the first two diseases mentioned, these can be communicated to man. Autopsy surveys of 10,000 persons in the U.S. have shown about 16% incidence of trichinosis, though it is estimated that on more thorough examinations the figures would rise to about 30%. These is evidence that the incidence of trichinosis in the swine population of the U.S. is decreasing.

Efforts to prevent the spread of trichinosis in man have resulted in an amendment to the United States Interstate Quarantine Regulations stipulating that no garbage may be shipped interstate for hog feeding unless first cooked at 212° F. for 30 minutes. New York, Washington, Oregon, and Kentucky have State regulations stipulating that garbage be cooked before being fed to hogs. The Dominion of Canada also has regulations of this type.

In England, several plants for the cooking of garbage used for hog feeding were constructed during the war as an aid in increasing the home production of pork. The Borough of Tottenham processes kitchen waste in steam-jacket vessels for 2 hours at 203° F. It is then cooled and sacked for livestock feed. Cooking whole garbage produces injurious acids, alkalies, and other substances which are derived from coffee grounds, citrus fruit rinds, and such, and which spread

thru the garbage. Some of the objections to cooking by hog raisers can probably be overcome by having the inedible portions manually separated before processing.

Only about 50 percent of the garbage produced in homes and restaurants can be consumed by hogs. Consequently, other means of disposal must be provided for inedible garbage as well as for rubbish and ashes. The economy of combined refuse collection is therefore not adaptable to the hog feeding method of disposal.

Reports from Los Angeles indicate that the food value of garbage for hogs is apparently decreasing since 60 pounds of pork were obtained per ton of garbage fed in 1923 compared with 30 pounds in 1940. One ton of garbage will feed daily 70 to 75 pigs between the weights of 50 to 100 pounds, or 50 to 60 pigs weighing between 100 and 150 pounds.

Hog Farm Sanitation is a tedious undertaking. Cleaning of grounds, pens, and feeding platforms should be done daily in order to keep down diseases among the animals and in order to keep rats, crows, buzzards, flies, and mosquitoes away. The disposal of uneaten garbage and hog manure constitutes a real problem. Ordinarily it is buried. Hog Farms will usually give rise to nuisance complaints unless located at a site well removed from centers of population.

The cost of maintaining good sanitation involves sanitary equipment for collecting and transporting hogs to farms, maintaining farms with enough warmth in winter and coolness in summer, locating farms on easily drained land with abundant water supply, fencing in the lots, constructing indoor housing for the pigs, and feeding platforms.

Feeding-lot sanitation is important. Such a lot on a large farm should have one or more feeding platforms. The platforms should be provided with a railing high enough to prevent garbage from being shoved off during feeding. Concrete platforms are better and should be at least 8 feet wide, 3 1/2 inches thick with 1/2 inch surface coat, and have a curb 6 to 8 inches high. There should be adequate drainage for such lot. It should be cleaned between each feeding and the surrounding ground should be plowed regularly. Pigs die from crowding or "piling up". In a pen each pig averaging 100 pounds in weight should have a minimum of 5 square feet of floor space; those averaging 200 pounds each, 8 square feet; those averaging 300 pounds, 11 square feet. Some estimates declare that adequate pen size is provided at the rate of 16 square feet of floor space for each 200 pounds, or 10 hogs per 200 square feet of floor space.

An individual pen should be provided for each brood sow at farrowing time, with a minimum size of 6 by 6 feet for gilts and 7 by 7 feet for large sows.

On being weaned young pigs may be kept in groups of 10 to 30 in a pen until they are 3 months old. When they begin to average 60 to 75 pounds each, they should be turned into comparatively large lots, 1/2 acre or more in size.

From the above, it can be readily seen that raising hogs requires every bit as much care and expense as raising milk cows. The lack of such care has already expressed itself in the fact that the people of the United States have a high rate of trichina infection.

Garbage feeding to hogs is a very extensive practice in our country and in very few instances is the practice carried on in a sanitary manner and to the best interest of the health of the people. Some towns maintain garbage dumps and allow great number of hogs to feed upon them so as to provide a cheap method of garbage disposal and at the same time a cheap method of raising pig stock. A cheap practice for economic gain is often an expensive practice in terms of human health, and can only be carried on in an uninformed community.

Incineration. The incineration of garbage and combustible rubbish has received considerable favorable attention during recent years. There also has been some interest in plants equipped to dry and burn sewage sludge combined with garbage and refuse. The production of electrical power from the burning of combustible rubbish and garbage has contributed to lower incineration costs in some places. From the standpoint of sanitation, well-operated incinerators are one of the most satisfactory methods of disposal.

Incinerators should be operated as continuously as possible at their design capacity for the best results. Ordinarily they should not be expected to operate more than 144 hours per week and should be designed for daily loads at least 150 percent of average. Since refuse trucks do not arrive at the plant uniformly during the 24 hours, facilities should be provided for the storage of the material at the plant to permit continuous and uniform stoking of the furnace with refuse.

Variations in moisture of combustible material in the waste will cause operational difficulties. The salvage of paper and other combustibles will affect the operation of incinerators by making it necessary in some cases to use auxiliary fuel. Cities with incinerators must provide other methods for the disposal of incombustible refuse.

In order to prevent odor and smoke nuisance from an incinerator, all combustion gases should be passed through a furnace temperature of 1,400° F. average and 1,250° F. minimum. Incinerators have been variously reported to produce from 15 to 50 percent ash from the material burned. This is commonly used for fill but creates an additional disposal problem and a need for rehandling in crowded areas. Frequently dumps consisting solely of incinerator residue have been found to harbor large numbers of rats.

The following items must be considered in computing incinerator operating costs:

1. Interest and amortization (approximately 10 percent of first total cost each year), labor, auxiliary fuel, electric power required for operation, repairs and replacements, and water.

2. Revenue from power when produced must be considered in relation to the above costs.

There are three types of incinerators: closed types, semi-closed types, and open types.

Closed Incinerators: This type is essentially a furnace equipped with fuel and drying grates and having a combustion chamber and a relatively high stack. There are two types of closed incinerators, the low temperature type and high temperature type. The low temperature operates on an average temperature of 1400 degrees F. and the high temperature type on a minimum temperature of 1800 degrees F. The cost of the former is lower than that of the latter, but it is difficult to operate the low temperature type so that its temperature be not reduced below 1200 degrees F. and thus prevent the combustion of the malodorous gases. The high temperature type effectively decomposes obnoxious gas under most circumstances, and thus is the preferable type since it eliminates the nuisances of odors.

A good incinerator is built on somewhat the following plan. The garbage is dumped onto an inclined drying grate thru a charging opening in the top of the incinerator, and the dried garbage slides down onto the fuel grate to be consumed. The superheated gases pass into a combustion chamber where they are decomposed into simple non-odorous gases by the heat. The arched roof of the furnace and a heavy wall of fire proof material prevent lateral expansion and distortion due to the high temperatures. A stack is provided which is about 50 feet high for 5 ton installations. A platform is provided for unloading garbage from wagons. Closed incinerators are made to dispose from 1 to 20 tons of garbage daily.

Advantages of closed incinerators:

1. Completely destroys garbage and malodorous gas.
2. Requires very little fuel to operate.
3. Can be operated near inhabited places.
4. The heat produced can be utilized to provide hot water or steam for washing garbage collection facilities.

Disadvantages of closed incinerator:

1. Not economical for small amounts of garbage (less than 1 ton daily.)
2. Construction cost comparatively high.
3. High temperatures render frequent repairs necessary.

Semi-closed Incinerator: This type embodies certain features of the closed type. Its stack is

low to assist in creating a draft, and it is protected from rain, wind, or flooding. The heat developed in the semi-closed incinerator is not great enough to decompose obnoxious gases. This type of incinerator can be effectively employed for small permanent installation such as hospitals, sanitariums and the like which are distant enough from inhabited places not to cause a nuisance. Because of the lower temperature they have considerably less capacity per unit of grate area. Usually they are built of ordinary brick instead of fire brick and therefore deteriorate rapidly.

Open incinerators are temporary installations used in camps and away from inhabited places. See Chapter on Temporary Measures of Sanitary Control.

Reduction: The reduction processing of garbage involves its heating and treating so that the grease can be recovered. Separate collection of garbage is required. While both the greases and residue or tankage have value, the cost of constructing, operating and maintaining a reduction plant is too high to make it practical for a community of less than 200,000 population. There are a number of such plants in the U.S. They produce plenty of odors and therefore their location is an important problem. Volatile and highly inflammable solvents are used to extract the grease. These solvents cause such a plant to be a potential fire danger. Due to the fact that the cost of operating such a plant plus the expense of collection and transportation of the garbage is usually greater than the profits derived from such industry, it becomes practical for such a plant to be operated only by a municipality where collection and transportation of garbage is an expense already present regardless of whether the garbage is to be processed or not.

There are two methods used for reduction of garbage:

1. Drying with heat: In this process, the garbage is first dried by heating and then treated with a solvent such as naphtha or gasoline to extract the grease. The solvent is then distilled from the extract and used again. The disadvantage of this method is that some of the grease is lost by being carbonized during the drying process and not all the grease is extracted from the dried garbage. The drying process produces very much odorous gases requiring treatment. The advantage of this process is the low cost of operation.

2. Cooking: In this process the garbage is put in large vats and cooked. Then the grease and water are pressed out of the soup. The solids are dried and treated with solvents for extracting the remaining grease. From the liquid pressed out of the soup, the grease is easily separated from the water. The advantage of this process is that most all the grease is recovered, and few odors are produced. The disadvantage is that the initial cost of such a plant is higher than that used in the drying process.

From the reduction process, considerable amounts of fats, greases, alcohol, glycerine, nitrogen, and potash may be recovered. We are accustomed, because of our almost unlimited supply of materials and the present high cost of processing garbage, to disregard the potentialities of the reduction method. But a psychology of conservation and more intercommunity cooperation can certainly decrease the costs and increase the efficiency of collection, transportation, and processing of large amounts of garbage. We Americans must begin to think in terms of conservation. We are entirely too wasteful.

Ordinary Burial: This is a method used for temporary control such as in camps.

Open dumps: The dumping of mixed refuse in isolated spots has been widely used. As long as sufficient low-cost land is available within a reasonable distance, the practice will have many advocates for reasons of economy.

The objections to it are so numerous that most cities are realizing the necessity for finding other methods of disposal. The gradual urbanization of the country is making it increasingly difficult to find acceptable dumping grounds without excessive hauls. Open dumps are not satisfactory to health authorities since they provide ideal breeding places for rats and other vermin, and usually constitute both a fire hazard and a smoke and odor nuisance. In addition, the nuisance produced by an open dump may be expected to result in a loss of property values in the vicinity.

Dumping into Streams: The dumping of garbage into streams and rivers has been outlawed by

the stream pollutions laws of our country. The dumping of garbage into large bodies of water such as lakes and oceans is not adequate, because these wastes are later washed ashore and interfere with sanitation of bathing resorts.

Composting. There is the belief by some sanitary engineers that the future development of sanitary engineering and sanitary science will lie in the direction of the conservation of materials now being wasted, of which municipal refuse is one of the most important. Two methods, both involving conservation of organic matter for use on the soil, are currently in early stages of development as practical answers to some of the refuse disposal problems of American cities. One envisions the grinding of garbage into the sewer, either in the individual household or at the municipal grinding stations strategically located throughout the city, whence it is digested and recovered along with sewage sludge. The other proposes to reduce the combined organic refuse of the community by a process of composting, to yield a humus which can be used either as a soil conditioner, or be reinforced to make both fertilizer and soil conditioning material.

For centuries something generally known as composting has been practiced by farmers throughout the world. It was a process of anaerobic fermentation of waste yielding incompletely reduced material, which, when placed in contact with soil bacteria, is then converted into stable humus by aerobic action. More recently a number of mechanized processes have been developed to carry out the anaerobic and aerobic processes under controlled conditions.

The principle steps in successful composting are: (1) Shred or grind material to be composted; (2) Adjust moisture content if necessary to 50 to 60% by adding paper, or 70 to 80% by adding straw at grinding time; (3) Place in piles or windrows 5 to 6 feet deep; (4) Maintain aerobic conditions by turning as necessary, possibly every third day; (5) Regrind at end of process for practical reasons.

What goes on during the process is: Thermophilic aerobic action which generates a temperature around 122° F. within 1 day, and about 158° F. in 3 to 4 days after fresh garbage is ground and placed in piles. If piles are too shallow excessive heat loss occurs, and when too deep the aerobic action is difficult to maintain. The high temperature is maintained for 11 to 14 days. The compost is finished when the carbon-nitrogen ratio is below 20 to 1, at which point it may be put on soil without danger of robbing the soil of nitrogen. Normal garbage with attendant paper will require about 3 weeks for processing. The more paper, the longer time required. The final product contains perhaps 1.5% nitrogen, 1% phosphorus pentoxide, and 1% potash. Higher original carbon content produces lower percentage of nitrogen in the final product. Addition of sewage sludge to the refuse will increase the final nitrogen content, as will also slaughter house and other high nitrogenous wastes.

Many problems of economy are still to be solved in relation to using this process.

Grinding of garbage for discharge to sewerage system. This method may be used in cities which discharge untreated sewage into large bodies of water, or to those equipped with sewage treatment plants designed for handling garbage. It is adaptable to the disposal of garbage only, and the practice to be followed will depend upon local conditions and facilities available.

Grinding and disposal with sewage can be carried on by two methods:

1. The soft garbage is reduced to finely divided particles by means of a special apparatus in each kitchen such as a comminutor or shredder, and the ground material is disposed of in drains which carry off the liquid wastes from the kitchen.

2. The garbage is collected as usual, but is ground into minute particles at the disposal plant and then put thru the disposal process with the sewage. There are a number of such plants in the United States which are functioning with some success. There are still a number of problems to be solved in connection with this disposal method, due to the fact that;

a. The gas production is greatly increased.

b. The clogging of the system by ground bones, eggshells and bottle caps due to their high specific gravity disrupts the plant too often.

c. The increased solids in supernatant fluids puts too heavy a load on the aeration system.

The Sanitary Landfill*

The sanitary landfill, primarily, meets public-health criteria, as well as such allied requirements as control of fire hazards and nuisance abatement. It satisfies the requirements of any sanitary method of refuse disposal:

It minimizes disease-vector breeding or sustenance by eliminating all possible harborage and food supply for rats, flies, and other vermin.

It adequately deals with the possibility of direct disease transmission. (Infected pork scraps contained in garbage are potential links in the chain of trichinosis infection in man, and also play an important role in the perpetuation of certain diseases of swine, such as vesicular exanthema. These diseases are primarily perpetuated by the practice of feeding undisinfected garbage to swine. In the case of trichinosis, the chain is completed when insufficiently cooked or raw pork products from trichina-infected swine are consumed by humans.)

Air pollution by smoke and odor is effectively controlled. Fire-hazard potential is kept to a minimum. The possibility of harmfully polluting surface and ground waters is minimized. Nuisance factors are effectively controlled; i.e., the system is esthetically acceptable, and noise is held to a minimum.

Selection of Site: The rule-of-thumb measure which has been used for years states that from 3/4 to 1 1/2 (or an average of 1) acres of land is required per 10,000 persons, and the depth of compacted refuse is to be about 7 feet.

However, depending on topography and desired finished grade, deeper fills may be constructed in larger cities by using layers up to 15 feet in depth so that less land area may be required.

The most accurate method of determining area requirements is, of course, by using actual measurements made during field tests. To assist in the calculation of preliminary estimates, the following data are included:

(a) Compaction ratio (volume of refuse after compaction, compared with the volume of refuse received at the fill) will vary generally from 1:2 to 1:4, depending on the type of refuse, compaction procedures, and depth of fill.

(b) Analysis of data obtained from 138 cities using the sanitary landfill method showed that the number of tons of refuse incorporated into the fills of 42 of the 44 cities which reported weight data varied from 0.14 to 1.67 tons per capita per year. The median was 0.53 tons per capita per year (2.9 pounds per capita per calendar day). In addition, volume data reported by 66 of the 138 cities was well distributed from 0.25 to 10 cubic yards per capita per year. The median was 2 cubic yards per capita per year.

(c) The average density of mixed refuse approximates 500 pounds per cubic yard when delivered to a fill. In areas where, or during seasons when, the ashes contained in the refuse are negligible, this density ordinarily approximates 350 pounds per cubic yard.

(d) Allowance should be made for volume occupied by the earth cover. This is generally a 2-foot final top cover, and up to a 1-foot covering on the sides and face of each cell. (A cell consists of one day's deposit of compacted refuse.)

In selecting sites for landfills, low areas such as ravines, swamps, and abandoned borrow pits are regarded as particularly suitable topography provided fill operations do not obstruct natural drainage courses. Earth should be available for cover materials, sandy soil being most desirable. Attempts to use gumbo clay for cover have not been successful because this material is subject to shrinkage cracks which prevent proper sealing of the deposited material. It is also undesirable from the standpoint of rodent control.

Fills should not be made where springs exist or be so located as to obstruct natural drainage channels. If possible, sites should be chosen so that prevailing winds will carry any occasional

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odors away from built-up areas. Odors have been observed over 1,000 feet to windward with a 15-mile-an-hour wind. In most cases it is believed odors will not be noticed more than 300 feet from the scene of operations.

The choice of a disposal site should be governed largely by the distance from sources of waste and by the availability of suitable access roads, bridges, etc. Refuse trucks should not be routed over main traffic arteries where this can be avoided.

Research by the University of Southern California indicates that:

(a) A sanitary landfill, if so located that no portion of it intercepts ground water, will not cause impairment of the ground water for either domestic or irrigational use.

(b) Rainfall alone in this area will not penetrate a 7.5-foot-thick landfill sufficiently to cause entry of leach into the underlying ground water.

With regard to location to minimize the possibility of underground pollution, the Illinois and Idaho Departments of Public Health have made the following recommendations:

(a) Landfill should not be built on exposed rock strata. A minimum of 30 feet clayey-till overburden should be kept between strata and refuse, unless studies indicate that a lesser depth be satisfactory.

(b) The fill should be located at least 500 feet from deep wells, unless studies indicate that subsurface seepage be not imminent.

(c) Garbage and refuse should not be placed in mines or other areas where resulting seepage or leach may carry waste to water-bearing strata or wells. It should be remembered that chemical pollution may emanate from a fill and probably could travel for long distances as compared to organic and bacterial pollution travel.

(d) Sanitary fills should not be located on or near springs.

(e) The state department of reclamation, state geologist, and the state department of public health should be consulted regarding any problems of possible underground pollution.

Method and Operation: Two important phases in manifesting the sanitary landfill system are method and operation. With suitable land available, the question of operational techniques must be decided. Under the original concept, sanitary landfill methods were placed into two broad categories, one called the area method and the other, the trench.

The area method is usually employed in uneven or low locations, where soil conditions in front of the face of the fill do not permit a crawler tractor to operate. The refuse is dumped, compacted, and covered with earth hauled from part of the same or another site or obtained from the site in use by means of a dragline excavating in front of the face of the fill.

In the trench method, cover material is obtained by excavating a trench. Earth from the first trench is used to build a ramp which is constructed to desired grade. Then refuse is dumped into the initial trench and compacted; earth cover is obtained by excavating an adjoining trench. Depending on the type of soil, about 3 feet are allowed between trenches.

Several years ago, in the search for more efficient means of operation, a method called the ramp or progressive slope, encompassing certain of the techniques of each of the other methods, was developed.

Basically, the progressive slope method employs a technique of obtaining cover material just ahead of the operating face. When applied to the trench method, an initial trench is excavated and a ramp is built. Instead of immediately starting excavation of a second trench, refuse is dumped into the first trench and compacted. Earth cover is obtained by further excavating that portion of the trench remaining free from refuse. A second trench is started when the operating area of the first trench becomes too small to permit further excavation, or when it is not desirable to deepen it further. The latter method is sometimes referred to as the moving trench method.

Similarly, in an adaptation of area trench techniques, this method may be employed by obtaining the cover just ahead of the face of the fill. The controlling factor here seems to be whether or not the equipment can operate in front of the face of the fill. The advantage of the

progressive slope method is that the earth cover hauling distance is shortened.

The equipment and personnel required to operate a fill properly will, of course, vary with the amount of refuse handled, characteristics of the site chosen (such as source of cover material), and the construction method employed. There are four major types of equipment that can be used in operating a sanitary landfill: namely:

(a) Track-type tractors equipped with a bullclam or front-end loader.
(b) Track-type tractor with bulldozer (and scraper where needed).
(c) Dragline.
(d) Wheeled-type tractor with bulldozer and scraper.

The various equipment companies have data based on experience with their respective equipment. Some approximations on the use of a tractor equipped to pick up and carry earth are as follows:

Contributing Population	Capacity	Number of Units
Up to 15,000	1 cubic yard	1
15,000 to 30,000	2 cubic yards	1
30,000 to 75,000	3 cubic yards	2

One manufacturer recommends the use of a scraper of 3.5-yard capacity in conjunction with a tractor-dozer in communities of 30,000 to 100,000 population. This combination is especially adaptable to hauling cover material from 200 to 500 feet. A bulldozer and a dragline are good when the fill is in an area where some factor, such as the water table, prevents operation of a tractor at the base of the fill. The dragline can operate from firm footing on top of the fill and still obtain the necessary cover material in advance of the face of the fill.

Wheeled-type tractors have application in the operation of sanitary landfills where especially long hauls on the site are required to provide cover. Generally, they are used in conjunction with track-type tractors that place and compact the refuse and are usually considered for use on the larger landfills. In addition, their use has proved advantageous in certain instances because they can be moved from one site to another under their own power.

Personnel: Data reported by the American Public Works Association, in 1948, indicate that an average of six men is required per 1,000 cubic yards of refuse disposed of per day in a sanitary landfill. The primary variable is, of course, the nature of the site being worked. Reported requirements varied from 10.6 men per 1,000 cubic yards per day at St. Petersburg, Fla., where tidal land was being reclaimed, to 3.3 men per 1,000 cubic yards deposited per day where conditions were more favorable.

Again referring to the sanitary landfill data reported by the previously mentioned 138 cities, all but two of 34 cities with populations of 15,000 or less, were operated by one man; of 38 cities with over 15,000 and under 50,000 persons, 15 used one man to run the entire fill operation, 18 used two men, and 3 reported the use of three men. The demarcation line between using one man and using two men varied widely, but usually occurred in the 16,000 to 25,000 population category. Of 14 cities with over 50,000 and under 100,000 persons, seven reported operating fills with two men, five with three men, and two with more than three men.

Winter and Wet-Weather Operation: Sanitary landfills can be operated in the United States throughout the year, even in extreme winter climates. In Mandan, N.D., a sanitary landfill was operated as an experimental project in 1949 through a winter during which temperatures as low as 44° F. below zero were experienced. Subsequently, many other cities have successfully operated sanitary landfills under similar climatic conditions. The Mandan experiment was carried on at a site having relatively sandy soil. As a result of experience there, the three following possible methods of facilitating year-round operations in extremely cold climate were advanced:

(a) The area should be scarified prior to the frost and should be insulated with material such as leaves (2-to 3-foot depth recommended).

(b) Trenches should be excavated in advance and cover material should be stockpiled for use during winter operation.

(c) Possibly, an undisturbed area should be excavated. (An undisturbed area is defined as an area which has not had the surface growth and earth compressed, for example, by numerous vehicles passing over it.)

Other recommendations with regard to equipment included emphasis on the need for ice and snow grousers, a heated cab for the tractor, and a heated garage for equipment storage and personnel.

Wet weather operating problems give rise to difficulties because maneuverability of collection trucks, as well as of landfill equipment, can be seriously impeded. The following ideas have been found useful through operating experience:

(a) Well-drained sites with sandy loam soil are preferable.

(b) Access roads should be all-weather roads.

(c) Such materials as ashes or planking should be stockpiled to make them available for the construction of firm surface lanes from permanent access roads to the area of operation when needed.

(d) In extremes, it may be necessary to dump some distance from the operating area and bulldoze material to the area of operation. This practice is advocated, in most instances, only as a final resort.

(e) Where the vehicular load is not prohibitive, the tractor can, in some instances, satisfactorily tow refuse trucks to the operation area.

(f) The use of alternate areas during a prolonged wet period may be desirable.

Salvage operations. Scavenging is not recommended. Experience has indicated that it may foster poor housekeeping and attendant nuisances. Where it is found locally expedient to permit scavenging, it should be rigidly controlled by restricting dumping hours, and having regular inspection, and adequate muncipal ordinances for enforcement of the proper use of the landfill, and by maintaining adequate cost records.

The board of experts appointed by the Surgeon General in the New York case made the following recommendations on landfill operation:

1. The disposal of wastes by the landfill method should be planned as an engineering project. Operations and maintenance should be under the direction of a sanitary engineer.

2. The face of the working fill should be kept as narrow as is consistent with proper operation of trucks and equipment in order that the area of waste material exposed during the operation day be minimal.

3. The exposed surface should be covered with earth as promptly as is consistent with proper operation and at the close of each day's operation both the surface and the face of the fill should be completely covered, the object being to make a closed cell of each day's deposit.

4. Sufficient standby equipment should be provided to prevent delay in covering, because of break-downs or peak loads.

5. Waste building material, concrete, or other bulky waste material which may furnish rat harborage should not be used for the final surface or side slopes, but should be promptly incorporated within the fill.

6. The final covering for surface and side slopes should be maintained at a depth of approximately 24 inches.

7. In case the finished fill has a boundary side slope, the toe of the slope should terminate in a sand-and gravel-filled ditch. This will prevent raveling of the toe with exposure of some of the waste material, will prevent the burrowing of rodents and finally will obviate puddles by permitting seepage from the fill to be absorbed into the ground.

8. Spraying of the exposed waste material and adjacent surface should be used when necessary to allay dust.

9. As a rule, the layer of refuse should not exceed an average depth of about 8 feet after compacting. Where deeper fills are necessary, the filling should be carried on in stages.

10. Control over the blowing of paper should be adequately maintained by the use of movable snow fencing.

11. While the maintenance of proper earth covering as hereinbefore recommended will to a large extent prevent fires, water under pressure should be available for fire-fighting purposes.

If scavengers be tolerated, they should be adequately supervised.

12. All collections of surface water resulting from these landfill operations should be drained, filled, or treated with effective chemicals so as to prevent mosquito production or allay disagreeable odors.

13. Where necessary, effective steps should be taken to prevent floatage of waste material into open water.

14. Inspection for and control of rodents should be maintained until fills are stabilized.

15. After the active period of the filling operations is completed, a maintenance program should be continued until the fill has become stabilized so as to insure prompt repair of cracks, depressions, and erosion of the surface and side slope.

16. Studies of the varied problems involved in landfill operations should be continued and should be included with researches into the biological, chemical, and physical activities, as well as the engineering, economic, and administrative aspects of the subject.

Operational Criteria. It has been indicated by experience that: 1. Where practical, compaction of refuse should be done in stages of shallow layers of about 12 inches in compacted thickness.

2. A deposit of about 6 inches to 1-foot of earth cover on the operating face over each day's deposit of refuse, topped with 24 inches when a trench or similar operating area is completed, has proven satisfactory.

3. Trenches should be constructed at least one and one-half times the width of the tractor and its equipment.

4. Large quantities of tree trimmings, logs, stumps, and similar material, should be burned at an appropriate time on a site not immediately akin to the operating area. Small quantities of such material may be successfully incorporated into the fill by placing it in the bottom of the trench or area being filled.

5. A structure or house, preferably portable, is desirable for use by personnel and for storage of tools and maintenance of equipment. Appropriate sanitary facilities should be provided.

Small-Community Operation: With proper planning and efficient operation, small communities of 5,000 or less should be able to operate a sanitary landfill effectively. On a project of this size, the tractor will be required only two or three hours daily (or for that matter on alternate days when alternate day collection is practiced), and thus is available the rest of the time for other municipal operations, such as gravel loading, snow removal, or street excavation. This arrangement would necessitate regulated dumping hours at the landfill site to prevent refuse from being scattered about during off days, evenings, and weekends.

Smaller communities might modify the landfill method by a form of sanitary trenching. It would usually be necessary to clean up the site before excavating a trench. Since the accumulation on small dumps can generally be moved only with heavy equipment, the trench may have to be excavated by rented equipment. The refuse should be compacted and covered at least twice a week in warm weather, and as often as practicable in the winter.

If heavy equipment cannot be obtained, an ordinary farm tractor and a small, front-end loading bucket or bulldozer blade can be used after such large items as tree limbs, car fenders, and barrels have been removed. Signs may be placed designating a separate dumping trench or area for such large objects. It would not be possible to control fires completely, but a deliberate program of burning household refuse is not recommended in this modified version of a community's sanitary landfill.

A simple outline of a program for a small community is:

(1) The public should be told how, why, and what is going to be done.

(2) The old dump should be cleaned up and an all-weather road built to the site using rented, heavy equipment if necessary.

(3) A trench should be dug, dirt should be stored at ends or on sides, and a specific area for large objects should be designated.

(4) Refuse in the trench should be worked over. The top and face should be covered with at least 2 feet of dirt on the schedule mentioned.

(5) Each spring, the large objects should be incorporated into the fill, the accumulated

brush burned, and a new trench dug.

Sanitary trenching, while less desirable than a sanitary landfill, is a vast improvement over the usual small open dump.

Economics: Experience has shown that a sanitary landfill can be operated at a cost of between 50 cents to about $1.50 per ton of refuse handled (1956). A representative cost figure should include cost of land, equipment, depreciation, labor, operational expenses, and miscellaneous contingencies.

Recommended Standards for Sanitary Landfill Operations

These Recommended Standards were developed as an aid to both public works and public health officials who share responsibility for providing and maintaining adequate refuse disposal operations.

Section 1. Design

Item 1. Topographic Maps. The design of the sanitary landfill shall include one or more topographic maps at a scale of not over 200 feet to the inch with 5-foot contour intervals. These maps shall show: the proposed fill area; any borrow area; access roads; grades for proper drainage of each lift required and a typical cross-section of a lift; special drainage devices if necessary; fencing; equipment shelter; existing and proposed utilities; employee facilities; and all other pertinent information to clearly indicate the orderly development, operations, and completion of the sanitary landfill.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) Topographic maps of the proposed fill area have been submitted. These maps shall contain pertinent information for the orderly development, conduct, and completion of the sanitary landfill.

Item 2. Geology. The geological characteristics of the proposed site shall be determined by on-site testing or from earlier reliable survey data.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) A report on sufficient exploratory investigations, including a series of borings, taken to the depth cover material will be removed and sufficient in number to give a valid indication of the underlying conditions, has been submitted, or

(2) Where only a few acres are involved and the geological formations are known to be consistent, satisfactory evidence of existing conditions has been submitted in lieu of borings.

Item 3. Characteristics of Cover Material. The soil used as cover material shall be of such character that it can be compacted to provide a tight seal, does not crack excessively when dry, and is relatively free of putrescible materials and large objects. Soil surveys, published by the Soil Conservation Service of the U.S. Department of Agriculture, are particularly helpful in locating sanitary landfill sites with the most suitable soil conditions.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) The cover material is "sandy loam" as defined by the Guide for Textural Classification, page 209, Soil Survey Manual, U.S.D.A. Handbook No. 18, available from the United States Department of Agriculture.

(2) The cover material available is not "sandy loam" but is of such character that it compacts well, does not crack excessively when dry, and is relatively free of putrescible materials and large objects.

Item 4. Water Pollution. Sanitary Landfill operations shall be limited to areas where water pollution is not likely to occur.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) Plans indicating suitable provisions to minimize or prevent water pollution have been submitted.

(2) A report on sufficient exploratory investigations of the site has been submitted indicating that problems of water pollution are not likely to occur if the plan of operation be followed.

Item 5. Equipment. Adequate numbers, types, and sizes of equipment shall be specified for operating the landfill in accordance with good engineering practice and with these Standards.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) The equipment specified will meet the performance requirements made necessary by the quantities of refuse expected, the landfill site, the operational plan, and these Standards.

Item 6. Plans and Specifications. All sanitary landfills shall be designed in accordance with these Standards by a registered engineer. Detailed plans, specifications, and necessary reports shall be submitted by the engineer to the State Department of Health for review and approval.

Satisfactory Compliance. -- This item shall be deemed to have been satisfied when: (1) The plans and specifications include the following background data: Present and estimated future contributory population, refuse quantities in weight and volume per capita per day, and ratio of maximum to average day.

(2) A registered professional engineer signs the plans and specifications and states that the sanitary landfill has been designed in accordance with these Standards.

(3) The plans, specifications, and necessary reports, including consideration of the items in these Standards, have been approved by the State Department of Health.

Section 2. Preparation of the Site

Item 7. Access. Access roads shall be designed and constructed so that traffic will flow smoothly and will not be interrupted by ordinary inclement weather. Access to the site by unauthorized persons shall be limited by suitable fencing.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) An all-weather access road, negotiable by loaded collection vehicles, has been provided to the entrance of the landfill site.

(2) Suitable fencing, with a gate that can be locked at the entrance of the landfill site, has been provided.

(3) a. Provisions have been made for all-weather access from the entrance gate of the site to an unloading area, or

b. All-weather access has been provided to an alternate sanitary landfill.

Item 8. Equipment Shelter. Suitable shelter for landfill equipment shall be provided.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) A permanent or temporary shelter of suitable size has been provided to accommodate the equipment and other necessary service supplies.

Item 9. Employee Facilities. Suitable shelter and sanitary facilities shall be provided for personnel.

Satisfactory Compliance. -- This item shall be deemed to have been satisfied when: (1) Permanent or temporary shelter has been constructed of adequate size, provided with safe drinking water, sanitary handwashing and toilet facilities, electricity, suitable heating facilities, and proper screening.

Item 10. Weighing Facilities. Provision shall be made for weighing all refuse delivered to the sanitary landfill.

Satisfactory Compliance. -- This item shall be deemed to have been satisfied when: (1) Suitable fixed or portable scales have been installed at the sanitary landfill to determine net weights delivered, or

(2) Other arrangements have been made to weigh and report the net weights of refuse delivered by each truck.

Item 11. Communications. Telephone or radio communications shall be provided at the sanitary landfill site.

Satisfactory Compliance. -- This item shall be deemed to have been satisfied when: (1) A reliable telephone or radio system has been installed at the sanitary landfill site.

Item 12. Fire Protection. Suitable measures shall be taken to control fires.

Satisfactory Compliance. -- This item shall be deemed to have been satisfied when:
(1) a. An adequate supply of water under pressure is available at the site, or
b. A stockpile of earth is maintained reasonably close to the working face of the fill, or
c. A nearby organized fire department will provide immediate service whenever called.
(2) Suitable fire extinguishers, maintained in working order, are kept on the equipment and in all buildings.

Section 3. Operations

Item 13. Limited Access. Access to a sanitary landfill shall be limited to those times when an attendant is on duty and only to those authorized to use the site for the disposal of refuse.

Satisfactory Compliance. -- This item shall be deemed to have been satisfied when: (1) The gate is open only when an attendant or equipment operator is on duty and is locked at all other times.
(2) Hours of operation and other limitations on access are displayed prominently at the entrance gate.
(3) a. An attendant is on duty during operating hours to prevent unauthorized persons from entering the area, or
b. On small landfills, the equipment operator is responsible for preventing unauthorized persons from entering the area.

Item 14. Unloading of Refuse. Unloading of refuse shall be continuously supervised.

Satisfactory Compliance. -- This item shall be deemed to have been satisfied when: (1) Appropriate signs are posted to indicate clearly where vehicles are to unload.
(2) a. An attendant is on duty during operating hours to direct unloading of refuse, or
b. On small landfills the equipment operator directs unloading of refuse.
(3) Unloading of refuse is confined to as small an area as possible.

Item 15. Blowing Paper. Blowing paper shall be controlled by providing a portable fence near the working area. The entire area shall be policed regularly.

Satisfactory Compliance. -- This item shall be deemed to have been satisfied when: (1) A portable fence is placed near the unloading and spreading area to catch windblown paper and other light materials.
(2) The portable fence and the surrounding area are policed daily and all scattered material collected and placed in the fill.

Item 16. Spreading and Compacting of Refuse. Refuse shall be spread and compacted in shallow layers not exceeding a depth of 2 feet of compacted material.

Satisfactory Compliance. -- This item shall be deemed to have been satisfied when: (1) Additions of refuse are spread evenly by repeated passages of landfill equipment.
(2) Each layer is compacted thoroughly to a depth not greater than approximately 2 feet.
(3) The refuse fill is continued to the total depth of lift (Item 17) by repeating 1 and 2 above.

Item 17. Depth of Lifts in Fill. Individual lifts in sanitary landfills shall be no greater than 8 feet in depth.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) All lifts are 8 feet or less in depth.

(2) No health hazards or nuisances result from the use of more than one lift.

Item 18. Daily Cover. A compacted layer of at least 6 inches of suitable cover material shall be placed on all exposed refuse by the end of each working day.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) The quality of the daily cover material meets the requirements specified in Item 3.

(2) At least 6 inches of well-compacted cover material (measured perpendicularly to the surface of the compacted refuse) is placed daily to cover completely all refuse deposited that day in the fill.

Item 19. Intermediate Cover. In all but the final lift of a landfill, a layer of suitable cover material compacted to a minimum depth of one foot shall be placed daily on all surfaces of the fill except those where operations will continue on the following working day.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) The quality of the intermediate cover material meets the requirements specified in Item 3.

(2) At least one foot of well-compacted cover material (measured perpendicularly to the surface of the compacted refuse) is placed daily on all surfaces of each lift on which another lift will be constructed within one year, except where 6 inches of daily cover are provided as specified in Item 18.

(3) The entire surface of the intermediate cover is inspected weekly and all cracked, eroded, and uneven areas repaired.

Item 20. Final Cover. A layer of suitable cover material compacted to a minimum thickness of 2 feet shall be placed over the entire surface of each portion of the final lift not later than one week following the placement of refuse within that portion.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) The quality of the final cover material meets the requirements specified in Item 3.

(2) At least 2 feet of well-compacted cover material (measured perpendicularly to the surface of the compacted refuse) is placed within a week of the completion of each portion of the final lift.

(3) Until completion of the landfill, the entire surface of the final cover is inspected monthly and all cracked, eroded, and uneven areas repaired.

Item 21. Equipment Maintenance. Provisions shall be made for the routine operational maintenance of equipment at the landfill site and for the prompt repair or replacement of landfill equipment.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) Adequate routine maintenance of sanitary landfill equipment is carried out.

(2) Inoperative equipment is repaired or replaced within 24 hours.

Item 22. Sewage Solids or Liquids and Other Hazardous Materials. Sewage solids or liquids (septic tank or cesspool pumpings and sewage sludge and grit) and other hazardous materials shall be disposed of in a sanitary landfill only if special provisions are made for such disposal.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) Suitable procedures are established and followed for disposal of hazardous materials.

Item 23. Large Items. Special provisions shall be made for the disposal of large, heavy, or bulky items at small landfills or at landfills operated with light equipment.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) A separate unloading area on the fill or an alternate site, operated in a sanitary manner, is utilized for the disposal of large items that cannot be handled with the other refuse. Burning of combustible materials is permissible if carried out as prescribed in Item 24.

Item 24. Burning. No garbage or refuse containing garbage shall be burned at the sanitary

landfill. Burning of select materials shall be severely restricted, and shall be conducted only with the permission of the appropriate authorities.

Satisfactory Compliance. This item shall be deemed to have been satisfied when: (1) No garbage or refuse containing garbage is burned at the landfill site.

(2) Burning of other materials is conducted only at a separate unloading area and with permission of and in accordance with regulations established by the local department of health, air pollution authority, and fire department. The regulations established should specify the hours and meteorologic conditions when burning may be permitted; prescribe safety precautions; stipulate the quantity, type, and condition of materials to be burned; and set forth any other necessary limitations.

Item 25. Salvage. When salvaging is permitted, it shall be so organized that it will not interfere with prompt sanitary disposal of refuse or create unsightliness or health hazards. Scavenging shall not be permitted.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) Salvage operations are conducted according to a definite plan and in a sanitary, orderly, and dependable manner with minimum interference to landfill operations.

(2) All salvaged materials are removed from the site or incorporated into the fill and covered by the end of each working day.

(3) No scavenging is conducted at the landfill.

Item 26. Vector Control. Conditions unfavorable for the production of insects and rodents shall be maintained by carrying out routine landfill operations promptly in a systematic manner. Supplemental vector control measures shall be instituted whenever necessary.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) There is proper maintenance of daily, intermediate, and final cover; adequate drainage; and compliance with other landfill Standards.

(2) Supplemental vector control measures are performed, when necessary, within 24 hours.

Item 27. Dust Control. Suitable control measures shall be taken wherever dust is a problem.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) Suitable measures are taken to control dust wherever necessary on the site or on the access road.

Item 28. Drainage of Surface Water. The entire site, including the fill surface, shall be graded and provided with drainage facilities to minimize runoff onto and into the fill, to prevent erosion or washing of the fill, to drain off rain water falling on the fill, and to prevent the collection of standing water.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) Diversion channels of adequate size and grade, based on runoff estimates from the area above the fill, are provided.

(2) The surface of the fill is smooth and graded to a minimum slope of 1 on 100.

(3) Maximum slope of the sides or toe of the completed fill is not greater than 1 on 2, the slope is adequately protected against erosion, and the bottom of the slope is protected against raveling and is so constructed as to provide either surface or sub-surface drainage to prevent ponding.

(4) Weekly inspections are made for standing water on the site and on the access road, and all accumulations are eliminated promptly.

Item 29. Completion of Landfill. An inspection of the entire site shall be made by a representative of State or local department of health before the earthmoving equipment is removed from the site. Any necessary corrective work shall be performed before the landfill project is accepted as completed. Arrangements shall be made for the repair of all cracked, eroded, and uneven areas in the final cover during the year following completion of the fill.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) A representative of the State or local department of health inspects and accepts the landfill project as completed before the earth-moving equipment is removed from the site.

(2) Arrangements are made so that the entire surface of the final cover is inspected monthly for one year and all cracked, eroded, and uneven areas repaired.

(3) A plat of the completed landfill and other operational records are filed as specified in Item 34.

Item 30. Supervision of Operation. A landfill operation shall be under the direction of a qualified individual.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) The landfill operation is directed by an individual deemed qualified as a Sanitary Landfill Supervisor by the State Department of Health.

Item 31. Animal Feeding. Domestic animals shall be excluded from the site.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) Domestic animals are excluded from the site.

Item 32. Accident Prevention and Safety. Employees shall be instructed in the principles of first aid and safety and in the specific operational procedures necessary to prevent accidents, including limitation of access. An adequate stock of first-aid supplies shall be maintained at the site.

Satisfactory Compliance. --This item shall be deemed to have been satisfied when: (1) At least one person trained in first aid is on duty during operating hours.

(2) An educational program is maintained on safety and first aid.

(3) Adequate first-aid supplies are available at the site at all times.

(4) Access to the site is limited as specified in Item 13.

Item 33. Inspection and Evaluation. Routine inspections and evaluations of landfill operations shall be made by a representative of the State or local department of health. A notice of any deficiencies, together with any recommendations for their correction, shall be provided to the owner or agent responsible for the use of the land; and the appropriate individual, firm, or governmental agency responsible for the landfill operation.

Satisfactory Compliance. -- This item shall be deemed to have been satisfied when: (1) A representative of the State or local department of health routinely inspects and evaluates the landfill operation: a. each month until the operation has been found to be satisfactory for 2 consectutive months, and b. at least once each 6 months hereafter.

(2) The landfill operation is evaluated according to these Standards.

(3) A notice of any deficiencies, together with any recommendations for their correction, is provided to the owner or agent responsible for the use of the land; and the appropriate individual firm, or governmental agency responsible for the landfill operation.

Refuse Disposal Regulations

The following Refuse Disposal regulations are from the Proposed Sanitary Code for Louisville and Jefferson County, Kentucky, which were developed by the Engineering Section Project of the American Public Health Association:

General Provisions

Definition

The following definitions of terms shall apply unless the context clearly indicates another

meaning or unless elsewhere expressly stated for specific application:

(The term "refuse" has already been defined earlier.)

The term "manure" shall mean that particular refuse which is the accumulation of animal or fowl droppings with or without added decomposible materials such as straw, grasses, or leaves and exclusive of human excrement.

The term "refuse collector" shall mean the person, firm, agency, or public body or employee or agent thereof who is or intends to be engaged in the collection and/or transportation of refuse, including garbage, swill, rubbish, waste matter, or manure in any part of the area of jurisdiction.

The term "swill collector" shall mean any person, firm, agency or public body, or any employee or agent thereof who is or intends to be engaged in the collection and/or transportation of swill exclusively.

The term "junk dealer" shall mean any person, firm, agency, or any employee or agent thereof who is or intends to be engaged in the collection and/or transportation, sorting, segregation, storing, exchange or sale of waste matter or rubbish, or of any old, used or secondhand materials of any kind, including cloth, rags, clothing, paper, bottles, rubber, iron, brass, copper, or other metal, furniture, used motor vehicles or the parts thereof; or of any other article which from its worn condition renders it practically useless for the purpose for which it was made and which is commonly classed as junk.

The term "salvage operation" shall mean any operation carried on by a person, or agent or employee of such person for the express purpose of reclaiming a portion of a substance, material, or goods purchased originally by such person for use without salvage, sorting or segregation which has been damaged, retained, or deemed unfit for the original purpose intended but is not yet classed as refuse.

The term "refuse disposal" shall mean the complete process required for the disposal of any refuse and shall include all tools, equipment, treatment space, buildings, structures, appurtenances and materials required to take refuse from a refuse collector at the premises line or other designated transfer point of a disposal area, and bury, burn, destroy or otherwise dispose of such refuse.

The term "disposal area" shall mean any site, location, tract of land, area, building, structure or premises used or intended to be used for refuse disposal.

The term "refuse container" shall mean any can, bucket, pail, box, bin, sack, basket, carton, hopper, crate or article constructed, built, purchased, installed or used for the purpose of holding an accumulation of refuse, or one or more of its component parts pending collection and/or disposal.

The term "private scavenger" shall mean a refuse collector who engages in the business of collection and transportation and/or disposal of refuse by specific hire or contract with another individual, firm, corporation, public agency or institution and does not include a public agency responsible by law for the collection of refuse in any given jurisdiction.

The term "refuse collection" shall mean the process whereby refuse and/or refuse containers containing refuse are taken from designated locations on any premises and are loaded into vehicles of any kind intended to transport from the premises to a disposal area, and whereby empty containers are returned to such designated location.

The term "transportation of refuse" shall mean that portion of the refuse disposal operation which provided for the hauling of refuse in bulk or in refuse containers to the designated transfer point at a disposal area.

The term "occupant" shall mean the person or persons occupying a dwelling unit or the person

operating, managing, or keeping any hotel, restaurant, food establishment, or the responsible head, manager, agent or proprietor of any industrial establishment, commercial establishment, business establishment, school, church, institution or premises wherein or whereon refuse accumulates or is likely to accumulate.

The term "night soil" shall mean any refuse material composed wholly or partly of human excrement and shall include the extracted contents from privies, privy vaults; latrines, septic tanks; cesspools; sanitary sewage grit chambers, screens or racks; grease traps; raw sewage sludge; and other such material retaining the characteristics of human excrement, provided that properly digested and dried sewage sludge from a public sewage treatment plant shall not be included.

The term "compost" shall mean the product resulting from the decomposition of leaves, straw, grasses and other such vegetable matter mixed with inorganic materials ordinarily forming a part of the soil such as sand or lime, loam, and used, useable or intended to be used as a fertilizer and soil conditioner.

The term "domestic garbage grinder" shall mean any device designed and intended for installation under a kitchen sink directly connected between the sink outlet and the house drainage system for the express purpose of grinding and pulverizing any or all types of domestic garbage and discharging the pulverized material into the house drainage system.

Approval of Plans

(These regulations are practically the same as for other facilities in relation to approval of plans, applications, specifications and disapproval. There are, however, several specific conditions under which exemption from approval may be granted.)

Exceptions shall be granted by the health officer whenever the refuse disposal area is:

a. On a farm premises over 500 feet from the nearest habitable dwelling unit.

b. Intended to be used only once for the disposal of waste matter or rubbish.

c. On an industrial premises over 1,000 feet from the nearest habitable dwelling and used or intended to be used only for the disposal of rubbish or waste matter.

d. The premises to which compost for private use is being delivered, or on which compost is being prepared for use on the premises and for use other than commercial sale.

e. A domestic garbage grinder discharging domestic garbage into a house drainage system connected to a public, semipublic or private sewerage system.

Protection, Supervision, Maintenance

Operating Permits Required

Every person, firm, corporation, municipality, public agency, or institution owning, managing, or operating a refuse collection service and/or disposal area for the use of or benefit of the public or a considerable number of persons, and every refuse collector, swill collector, junk dealer, or private scavenger, and every person who operates a feeding platform for feeding garbage or swill to swine shall hold an unrevoked permit for the operation thereof issued by the health department unless specifically exempted from such permit requirement.

All disposal areas exempt from approval of plans as stated herein shall be exempted from the requirement of an operating permit, but shall conform to all other requirements of the sanitary code.

Every domestic garbage grinder installation shall be registered with the health department.

An industrial, commercial or business establishment operating its own collection service entirely for the benefit of such establishment under one ownership and for no other establishment and disposing of refuse so collected at a public disposal area need not have an operating permit, but shall register the service with the health department and shall comply with all sanitary requirements for collection and transportation of refuse.

The owner of a farm collecting refuse entirely from the premises so owned and disposing of such refuse on the premises so owned or at a public refuse disposal area is exempted from the

permit requirement, but shall comply with all sanitary requirements for collection and transportation and/or disposal of such refuse.

The owner or occupant of any dwelling unit shall not require an operating permit for feeding table scraps, swill or garbage to animals or fowl owned by him on his own premises, or for collecting and transporting refuse from such premises in a vehicle owned or operated by him to a public disposal area but shall comply with all sanitary requirements for collection and/or transportation and disposal of such refuse.

(For those who must hold an operating permit the regulations are practically the same as for other sanitary facilities relating to permit forms, the posting of permit, revocation of permit, and expiration of permit.)

Investigation

The engineer director shall make such surveys, studies, investigations, inspections and visits to any place or premises wherein refuse may accumulate and to all refuse collection, transportation and disposal sites, locations, equipment, and premises for the purpose of ascertaining the status of compliance or the ability to comply with the requirements of this chapter and all applicable provisions of the sanitary code.

The engineer director shall collect or have collected and shall analyze or cause to have analyzed such samples of refuse or any other samples or specimens of animals, insects, materials or substances from a premises accumulating refuse, or transportation vehicle, or disposal area, as may be required to determine compliance with the standards and requirements of the sanitary code.

No operating permit shall be issued before a complete investigation of the premises, equipment, plan of operation, schedules of collection, places of disposal, and other pertinent information indicative of ability to comply with all standards and requirements have been made.

A statement of all special terms and conditions deemed necessary to assure compliance with the sanitary code shall be reported to the permit applicant when the operating permit is issued.

The issuance of the operating permit may be withheld or denied pending compliance with certain terms and conditions stated in writing and transmitted to the applicant in lieu of an operating permit.

A copy of the permit approval or denial together with the report shall be filed by the health officer with the planning commission and the department of public works of any municipality affected by the permit.

Reports and Records

Every person operating or proposing to operate a refuse collection, transportation or disposal service or any combination thereof, and every employee, agent, or contractor of such person shall furnish information and records as may be required by the health officer to determine the ability to comply, or the status of compliance with standards and requirements of the sanitary code.

All operators of collection, transportation or disposal services shall keep and maintain such operating records as the health officer may require to ascertain the extent of compliance with the sanitary code and shall, if requested by the health officer, submit periodic reports on such operations.

Responsibilities

Every person, occupant, owner, or permit holder shall have the duty of maintaining premises or equipment under his supervision, or containers, or disposal areas, in compliance with the requirements of the sanitary code.

Failure to carry out such duties herein or elsewhere required for the sanitary accumulation, collection, transportation, and disposal of refuse shall be deemed a misdemeanor, and the

presence of garbage or refuse in any place or in any condition not meeting the requirements of the sanitary code is declared a nuisance.

It shall be the duty of every tenant, lessee or occupant of any private dwelling house, the keeper of a hotel, restaurant, eating house, boarding house or other building where meals are served; the owner of every flat or apartment house, trailer camp, hotel, auto court, and of every other person having garbage, rubbish, or waste matter to provide and keep within said building or on the lot on which the building or business is situated, suitable and sufficient watertight galvanized metal containers of sufficient size to handle the accumulation of garbage, rubbish or waste matter on the premises during the interval between collections without being filled to within 4 inches of the top.

All refuse containers shall meet the requirements of the health officer as provided hereinafter.

Containers shall be placed by the occupant in a place designated by law, or if not so designated, in a place or location accessible to the collector, and acceptable to the health officer.

No refuse container shall be placed upon any street, alley, sidewalk, footpath, or any public place whatsoever except for the period of time immediately prior to collection and not to exceed three hours after collection unless specifically authorized by the health officer.

In business areas the health officer may require immediate removal of empty containers from public places.

Containers for the receipt of accumulation of rubbish may be placed in parks, recreation areas, places of public assembly, and along public ways. provided that they are plainly marked, "This container is for rubbish only."

Garbage containers in such places shall be placed only in designated locations acceptable to the health officer.

Garbage and rubbish shall be collected and containers shall be emptied not less than once per week and may be required to be collected or emptied more frequently for compliance with other provisions of the sanitary code.

Outlying business areas shall be provided with collection service not less than two times per week.

Public markets, and all food establishments producing putrescible wastes, and congested business areas shall be provided with collection service every day.

Waste matter shall be placed for collection and collected at a frequency which precludes the possibility of unsightly, unclean, or unhealthful premises, or the occurrence of a nuisance, and in no event shall be less than once every two weeks.

No person shall remove or permit the removal of any refuse placed in containers, or placed in an approved manner for collection except by an authorized collector.

The collector shall transfer the contents of all containers into the vehicle provided therefor, without spilling any garbage, swill, rubbish, or waste matter on stairs, walks, yards, or streets.

The collector shall clean up all garbage, swill, rubbish, or waste matter spilled during collection and shall completely empty containers and replace lids.

The collector while collecting in early morning hours shall use every precaution to prevent unnecessary noises.

The collector shall not damage cans or property while making collections and shall return containers to their proper locations or designated place.

No person shall throw or deposit any garbage, swill, rubbish or waste matter or cause the same to be thrown or deposited upon any street, alley, gutter, park, or other public way or throw or deposit the same in or upon any premises or vacant lot or in any water or waterway thereto, or store or keep the same except in containers as required by this code.

No person shall store, deposit or keep refuse in any place or in any manner where rodents can have access to or feed thereon, or can use such refuse as a harborage, nest or breeding place.

No person shall deposit or cause to be deposited any refuse in any place unauthorized for disposal in the area of jurisdiction.

When acceptable to the health officer, the owner of a premises and any public agency having jurisdiction, rubbish and waste matter may be placed in low areas and low lots when properly filled, leveled and covered and when such practice is not likely to create an unsanitary condition or a nuisance.

The owner of the property receiving such deposit will be held responsible for any insanitary condition or nuisances resulting from such deposit.

No person shall burn garbage, swill, or rubbish at any place, or in any manner violating a provision of the sanitary code or likely to create a health hazard or a nuisance.

Under no circumstances shall any material, causing excessive smoke, liberating a toxic substance on combustion, or producing a noxious odor likely to affect the occupant of any premises, be burned except under conditions and in equipment approved by the health officer or the combustion engineer or both.

Discarded fluorescent lighting tubes and mercury vapor lamps shall not be present in any refuse intended to be burned under any circumstance, but shall be disposed of in authorized disposal area by burial.

The occasional burning of small quantities of dry rubbish on private premises under controlled conditions shall be acceptable provided the above conditions be complied with in all other respects, and provided such practice be permissable under existing laws or rules and regulations of any other agency having jurisdiction.

No person in any municipality or in any recognized community shall bury garbage or swill except in an authorized disposal area.

In all new buildings and in all buildings renovated after the effective date hereof, when garbage is produced above the second story, said new buildings and all buildings hereafter renovated shall be provided with an approved metal garbage chute or chutes so that the garbage may be placed in the garbage cans or containers on the ground level. All such garbage chutes shall be approved as to types and construction by the building inspector and the engineer director.

All rubbish, such as rags, used clothing, bedding, mattresses, shoes and other material which may carry infectious or contagious substances or communicable diseases shall be taken as directly as possible on the day of collection to the place of disposal. The collector shall not retain any material of this character nor carry the same to any premises for storage, segregation or use, except as follows.

Such articles, when kept separate from refuse, may be purchased or collected by a junk dealer who shall clean and sterilize each and every article by an approved method before placing it with clean articles and before offering such articles to another person.

Every vehicle used for the collection of refuse shall be of a design and type suitably constructed for the intended use, and acceptable to the health department and the department of public works having jurisdiction.

Each person, building contractor, construction contractor, or subcontractor engaged in the

construction, repair, or demolition of any building or structure or part thereof, shall remove and dispose of in an authorized manner from any street, alley, gutter, park, sidewalk, curbing, curb space, any public way or any premises not owned by him all waste matter or rubbish deposited thereon in connection with that portion of the repair, construction, or demolition work under his special or general supervision.

Such refuse, waste matter and rubbish shall be cleaned up, removed, and disposed of in a sanitary manner within 7 days of the final cessation of work on such building or structure or part thereof unless otherwise specifically authorized by the health officer, or the department of public works, or the building inspector.

No person may pick over, sort, segregate or salvage any refuse deposited in an authorized disposal area without holding an unrevoked permit to operate as junk dealer issued by the health department and only such articles as may be specified in such operating permit shall be reclaimed from a disposal area.

No article may be reclaimed and placed with any clean article owned or kept by a junk dealer, or offered by a junk dealer unless it has been thoroughly cleaned of putrescible matter, and sterilized if necessary, to comply with such standards of cleanliness as determined by the health officer to be necessary to protect the health of the public, and to avoid the creation of a nuisance.

Any person responsible for the feeding of swine on garbage or swill produced at any other point than a farm premises on which such swine are located shall construct and install feeding platforms of sanitary construction and shall maintain the premises in a sanitary manner at all times, and shall dispose of the uneaten residue of garbage or swill within 24 hours of the original deposit of such refuse on feeding platforms in a manner complying with all provisions of the sanitary code.

The person responsible shall hold a specific permit provision for the feeding of swine as a part of the disposal area permit required by this Code before allowing the feeding of swine on garbage or swill transported to the premises.

No person, owner, agent or occupant of a lot or premises whereon a building of any kind may exist or of a vacant lot shall allow any collection of garbage, rubbish, waste matter or filth of any description to remain on such lot or premises longer than three days or any shorter period of time specified by the health officer, after the date of a written notice issued by the health officer or his agent to remove the offending material.

No person shall transport night soil through, along, on, or in any street, alley, public way or public place in the area of jurisdiction where such practice is prohibited by law and in any event night soil shall be transported only when permitted by this Code and in vehicles meeting the requirements established.

No manure shall be transported along any public street, alley, public way, or highway in area of jurisdiction unless such vehicle be tight and so constructed and loaded so that no manure can fall through or out of such vehicle, and unless such material be protected by a closed in top, or canvas cover; or be placed in a container kept closed.

No receptacle shall be constructed or used for holding manure the bottom of which is below the surface of the surrounding earth unless it be constructed of watertight construction and drained in a manner acceptable to the health officer.

Manure shall be removed from stables, barns, veterinary hospitals and all similar places within the area of jurisdiction at the expense of the owner and on the owner's responsibility in a manner acceptable to the health officer.

Manure which may be well rotten or classified as compost may be used as fertilizer, but manure having any considerable odor or likely to cause nuisance shall be used only under such circumstances as the health officer shall permit.

All manure resulting from the keeping of any animal, fowl, livestock, or game shall be accumulated in sanitary flyproof containers and collected and disposed of in a sanitary manner.

The accumulation, collection, and disposal of such material in any manner not conforming with the standards and requirements of the sanitary code is deemed to be a misdemeanor, and the insanitary accumulation, collection or disposal of such substance is declared a nuisance.

Every person who is the owner or custodian of any animals, fowl, livestock, or game which has died other than by slaughter for food; any animal offal from slaughter houses, slaughter pens, or any offal or putrescible waste from any place where meat, fish, poultry, game or fowl are sold or handled or discarded as unfit for food, or spoiled, or condemned shall dispose of the remains, carcasses, or parts of entrails thereof within the next available period of daylight after such death or accumulation in a sanitary manner and in conformance with all requirements and orders of the health officer.

No dog or other animals shall be fed on the uncooked offal or viscera obtained from any slaughter house, poultry killing house or fish market. Under no circumstances shall any person knowingly feed uncooked pork scraps, trimmings or muscle tissue to swine.

All dead animals which are found on or in any public street, alley, parkway, public way, or on public property shall be reported to the department of public works in a municipality and to the highway department in unincorporated areas, and that department so notified shall be held responsible for the collection within the day reported of the carcass of such animal and the delivery of such carcass without charge to the municipality or the county.

No person shall throw or deposit any refuse, garbage, rubbish, waste matter, or animal or animal carcass in or near any sewer manhold or stormwater catch basin unless specifically authorized as to both substance and place of deposit by the health department and the department of public works, or by the health department and the Metropolitan Sewer District wherever that agency has jurisdiction.

Standards

Standards for Accumulation of Refuse

The following standards and requirements are established as a minimum for the sanitary accumulation and storage of refuse pending collection:

Garbage containers for other than bulk accumulation shall be galvanized metal containers not exceeding 30 gallons capacity, in good repair, leakproof, rodent proof, and free from holes.

Containers shall be fitted with tight fitting metal covers and such covers shall be removed only at times of filling or emptying.

Containers over 10 gallons capacity shall be equipped with handles opposite, and containers 10 gallons or under shall be provided with a bail and both bails and handles shall be adequate to lift the weight of a full container without bending or breaking.

Containers shall be placed in the designated place for collection immediately prior to the time of collection and shall be removed from any public area or way as soon thereafter as possible and not exceeding three hours after collection.

When collection time is prior to 8:00 a. m. in residential areas the containers may be placed in the designated area the night before.

The place where containers are kept pending collection shall be clean, free of spilled garbage, or foul smelling water or residue.

The container shall be set on an impervious well-drained base.

Rubbish shall be held and stored in fire-resistant containers in any industrial, commercial, or business structure, and in a container acceptable to the health department and the fire prevention

bureau having jurisdiction in any other building or structure.

Ordinary accumulations of rubbish between collections may be placed at the designated collection place in any container of size and shape easily lifted and handled without spillage by the collector.

Extraordinary accumulations of rubbish shall be placed for collection in containers acceptable to the collector, the health department, and the department of public works.

Tree trimmings may be placed for collection outside of a container provided such trimmings are secured in bundles of convenient size and weight and do not exceed four feet in length.

Waste matter shall be held and stored in appropriate containers of wood, metal, or paper board.

Ashes shall be placed only in metal containers with covers, and other waste material shall be placed in sturdy well-built containers which will not break, fall apart, rip or tear while being handled by the collector, or shall be secured in neat bundles, easily handled by the collector and shall not exceed 4 feet in length.

Bulk handling or storage of refuse of any character shall be subject to review by the health department, and the owner or occupant of any industrial, commercial or business establishment shall make such provisions as the health officer may require for the sanitary storage and collection of such refuse as may be produced in bulk.

Standards for the Collection of Refuse

The following standards and requirements are established as a minimum for the sanitary collection of refuse:

Unless otherwise specifically exempted the refuse collector shall operate under an unrevoked permit issued by the health department.

The collector shall empty and return all containers to the designated collection place without damage.

Paper and all other temporary containers may be placed in collection vehicle unemptied unless the premises occupant has attached a specific notice in a conspicuous place on the container requesting "Return to Owner" in legible characters of a size easily read by the collector.

The collector shall not dent, bend, punch holes in or otherwise damage or alter the condition of a container properly marked.

A container in poor repair and not meeting the requirements above shall be tagged securely by the collector with a notice to repair or replace the container.

A duplicate of such notice shall be filed with the health department and in the principal office of the collector.

A container found to have been tagged as above on a subsequent collection and which is still not in compliance with container requirements shall have affixed thereon a condemned tag or seal.

A notification of this action shall be filed with the health department and in the principal office of the collector.

Thereafter the collector shall not collect the contents of a condemned container and the container owner shall be deemed to have committed a nuisance.

The health officer, on receipt of the notice filed in accordance with above, may investigate the condition reported, and, upon receipt of the notice filed in accordance with above, shall investigate and, if the conditions as reported be found in fact shall proceed to abate the nuisance by

whatever means is within the law.

The collector shall not leave behind the spilled contents of any container, or refuse falling out of any collection vehicle, or any refuse properly placed in the designated collection place.

Any person observing any violation of this section shall report the permit number of the vehicle and the exact location of the violation to the health department and to the principal office of the collector.

The collector, if a private scavenger or a refuse collector collecting refuse for which a fee is charged according to a regular schedule of fees filed with the department of public works and the health department, need not collect refuse from any premises in arrears two months on the payment of the prescribed fees.

When collection is stopped from any premises for the reason cited above, a notice of cessation and the cause therefor shall be filed with the health department.

The health department shall investigate the premises where such service has ceased, and if it shall be determined that refuse from such premises is not being collected and disposed of in compliance with the provisions of the sanitary code, appropriate action to correct the condition shall be taken, and any nuisance found to exist shall be abated.

Standards for the Transportation of Refuse

The following standards and requirements are established as minimum for the sanitary transportation of refuse:

Every vehicle used for the transportation of refuse shall be owned and/or operated under the supervision of a person holding an unrevoked operating permit to transport refuse unless exempted as prescribed hereinbefore.

Every vehicle used for the transportation of refuse shall have a hauling body constructed of metal, or shall have a metal lining on floor and all side walls.

All joints in the hauling body shall be effectively closed and smooth so that no drippage or leakage of draining water or liquid or any debris can occur.

Every vehicle shall be provided with a means of covering the refuse to be hauled and of keeping such refuse securely within the hauling body.

The hauling body shall be provided with a tight metal hood having adequate openings fitted with smoothly operating loading and unloading doors, or shall be provided with heavy tarpaulin or other canvas cover fitted with proper eyes, grommets and tie ropes and hooks whereby the cover can be held securely over the loaded refuse in a manner acceptable to the health department.

Every vehicle shall be kept well painted, clean and in good repair.

Every vehicle used for carrying garbage or swill shall be steam cleaned as often as may be necessary to prevent persistant odors and in any event shall be so cleaned once per week.

Every vehicle used for hauling garbage shall be steam cleaned before being used for any other purpose.

Every vehicle used for transporting refuse shall carry a legend on the side wall of the hauling body.

The legend shall be painted on the body, or if the vehicle has other uses the legend may be placed on a separate durable metal or wood plaque which shall be firmly fixed to the vehicle when used for refuse collection and transportation.

No vehicle without permanent cover shall be loaded with garbage or swill to a level above the

side wall height.

No vehicle shall be loaded with rubbish, waste matter or junk in a manner which will permit material to swing off, fall out, or jar loose and fall to the ground while in motion.

Loose paper, trash and small materials shall be secured against any wind dispersal, jiggling, or jarring which will allow such material to blow or fall out of the vehicle.

Whenever vehicles are to be used for the transportation of containers holding garbage, swill, or waste matter, the containers so carried shall meet the requirements for containers set forth hereinbefore.

Standards for Disposal Areas

The following standards and requirements are established as a minimum for the sanitary disposal of refuse:

Every disposal area shall be operated under an unrevoked permit issued by the health department unless specifically exempted as prescribed hereinbefore.

Areas which are used or intended to be used for the fill method of garbage disposal shall meet the following requirements:

The total property area shall be adequate to hold all refuse accepted for the entire period of time during which it is proposed to operate the dump. The estimates of capacity shall be supported with competent engineering data.

There shall be no dwelling units closer than 500 feet to any portion of the premises designated as a disposal area.

No person shall be permitted to occupy the premises designated as a disposal area for living or sleeping purposes except the authorized attendent and he only for resting purposes while working or guarding the area.

The disposal area shall be as free of standing water as is feasible and practicable.

No plan for a new disposal area shall be approved if that area be subject to flood and be not provided with sufficient natural or artificial drainage to keep the disposal area free of standing water.

Drainage from garbage or swill disposal shall be handled as sewage and is subject to the provisions for sewage disposal.

The disposal area shall be accessible at all times over a hard surfaced roadway which shall be kept free of all hazards to vehicles or vehicle tires by the permit holder for a distance of 500 feet beyond the disposal area premises.

The property shall be provided with adequate facilities for extinguishing fires, and if no fire water service be available from a public water system, there shall be a water supply on the premises providing not less than 500 gallons per minute at 40 pounds per square inch.

There shall be provided in addition one mobile foam type extinguisher of a design and capacity acceptable to the fire prevention authority having jurisdiction as suitable for the purpose intended.

No fire shall be permitted to continue burning in either covered or uncovered material.

All waste materials, refuse, garbage, and rubbish shall be covered with a fill of earth or other material acceptable to the health department within 24 hours of arrival at the disposal area.

The depth of cover shall be determined by the engineer director on the basis of the character of fill material, but in no event shall the depth of cover be less than 12 inches solid cover free of cracks and extrusions of refuse.

Cover material shall be so placed that settling by weather, rain, compaction, or decomposition will not open up cracks or allow extrusions of refuse within six months' time.

The disposal area shall have all required or necessary equipment comprised of bulldozer, or clam, or bull clam, and compactor, or equivalent equipment in sufficient capacity and of such operating quality that the fill can be covered according to schedules required.

All such equipment shall be serviceable, and kept serviceable in keeping with the disposal area need.

There shall be a responsible person in charge of the disposal area at all times.

There shall be personnel as may be required to keep all dumping operations on schedule, and to keep the roadways free of debris, trash or obstacles, and to keep a tidy appearance over the entire disposal area.

Sorting, picking, and salvage shall be permitted only under strict supervision.

The operator shall keep an accurate record by weight, volume, or numerical count as appropriate for the articles salvaged and the disposition of all salvaged articles.

Sorting, picking, and salvage records shall be available to the health officer and the police having jurisdiction at all times.

The salvaging of food in any form in or out of a container is prohibited.

Salvaged bottles or other articles of glass shall be cleaned and disinfected in a manner satisfactory to the health department.

All clothes, cloth, rags, bedding, upholstered furniture or any textile of cotton, kapok, wool, or other such material shall be salvaged only when sterilizing equipment to treat all such articles is provided on the disposal area premises, and any such material so salvaged shall be sterilized within the day it is salvaged.

If the disposal area be open to the public, the character of the materials accepted at the disposal area shall be listed and posted at the premises entrance or in the premises office which shall be adjacent to the entrance.

A duplicate of such list shall be filed with the health department and with the department of public works having jurisdiction.

The disposal area operator or person in charge shall keep a record of the source of material and the estimated volume, or tonnage disposed of in such form as may be required by the health officer or the department of public works or both.

The record shall divide materials received into sources as private individuals; industrial establishments; commercial establishments; poultry killing, or similar processing plant; and municipal contractor collection service.

Private scavengers shall keep sufficiently accurate records to provide the above information to the disposal area operator.

The premises shall be maintained free of rats and rodents, fly breeding and mosquito breeding at all times.

Incinerators may be used for the disposal, burning and destruction of refuse collected by municipal refuse collectors, provided that:

The incinerator be under the direction or supervision of some responsible municipal official, qualified by training and experience to operate such incinerator equipment;

The incinerator complies with all requirements for combustion type fuel fired equipment as provided in this Code;

The premises, loading floor, and ash floor be kept clean and free from objectionable odors and putrescible material;

All loading floors shall be cleaned and hosed down thoroughly at the end of each day's run;

Waste matter permitted on occasion to be used as fill material on vacant lots and in low areas shall be so placed and compacted that no rat harborage or place where rodents may live easily is provided or place where mosquitoes may breed as a result of such filling, or that no nuisance or hazard is created.

Domestic garbage grinders shall be permitted whenever the public sewerage system street sewer is 8 inches or larger in diameter unless specifically prohibited for good cause by the public works department, or the Metropolitan Sewer District wherever it has jurisdiction.

When the sewerage system is a semi-public or a private sewerage system the requirements for sludge capacity in the septic tank or digestor shall be increased at the rate of 1/2 pound dry solids per capita per day; the allowance for flow capacity shall be increased 2 percent; and the allowance for any filter treatment shall recognize a 25 percent increase in B. O. D. loading.

No garbage shall be permitted in the house drainage system which has not been thoroughly macerated and pulverized to a size passing a 1/16 inch screen.

All domestic garbage grinders shall be installed in compliance with the requirements of this Code.

Salvaged Material — Junk

Permits Required

Every person, firm or corporation desiring to engage in the collection and/or disposal of junk, old, used or second-hand material of any kind including cloth, rags, clothing, paper, rubbish, bottles, rubber, iron, brass, copper, or other metal, furniture, motor parts or vehicle parts, or any other article whose condition renders it practically useless so as to be classified as junk shall hold an unrevoked permit to do so in accordance with the provisions hereinbefore.

Materials which should otherwise be classified as rubbish, or waste matter shall be classified as junk when ownership of such material passes directly from an owner to a junk dealer.

Rubbish or waste matter deposited in a refuse container for collection by an authorized collection service shall not be reclaimed by either owner, refuse collector, disposal area operator, or junk dealer, except as provided therefor under "standards" hereinbefore, and no permit issued to a junk dealer shall be provided to grant that right or permission except as specifically provided hereinbefore.

No permit shall be issued for the collection of any garbage, waste food, damaged food, or condemned or retained food or food product by a junk dealer.

Any salvage of damaged food or food products shall be supervised by the health department and shall be done by persons acceptable to the health department in a manner allowed under a special salvage permit issued for each individual salvage operation and shall be at the sole cost and expense of the owner of such damaged food.

Records shall be furnished by junk dealers, salvage operators, and employees thereof as required hereinbefore.

Every junk dealer or person engaged in food salvage operation applying for an operating permit shall furnish any information requested by the health officer for the purpose of ascertaining ability to comply with the sanitary code.

Standards

The following minimum standards shall be complied with by junk dealers:

Every dealer shall have a premises and shelter satisfactory to the health officer and meeting all building requirements of the building inspector and the fire prevention authority.

Any clothing, rags, textiles of cotton, hair, felt, leather, rubber, kapok, or woolen or other similar materials shall be kept in a clean dry place, free from mildew, fungus growth and all damaging elements, and no such material showing evidence of dampness, or damage beyond ordinary wear, use, or storage shall be sold or offered as or for use as a garment, an article of furniture, or clothing of any sort.

All materials kept or stored on or in the premises shall be piled, stacked, placed in bins, lockers, or containers in such manner that no portion of the premises can be or is likely to be a rat harborage, or a place of vermin infestation.

Sufficient aisle ways shall be maintained clear and unobstructed so that the entire premises or any portion of the premises can be investigated and inspected.

If the business be not entirely enclosed in a building, the exterior premises shall be enclosed by a tight fence of wood or other material satisfactory to the health officer.

Tight shall mean that no article within the premises may be passed surreptitiously or otherwise through the fence.

All secondhand glassware, bottles, or any other container which is intended to be used for holding food or drink shall be cleaned and disinfected when such material is brought to the premises, or on the premises before such material is mixed with clean articles on the premises.

Cleaning and disinfecting shall be accomplished in a manner satisfactory to the health officer.

Storage of all clean articles shall be such as to keep them clean until sold or disposed of.

Every article of upholstery, furniture containing hair cloth, felt, kapok, wool or similar material, articles of clothing, footwear, rags, clothes and all such articles of like character shall be sterilized in a manner acceptable to the health officer before being placed with disinfected or sterilized articles, or before being offered to any person.

All sanitary conveniences, facilities, water supply, lighting, ventilation, heating and every other such requirement shall conform to the standards and requirements for industrial establishments set forth under this Code.

The following standards and requirements shall be complied with by food salvage operators:

All applicable standards for the preservation of food quality established in this Code shall be complied with, and a salvaged food product failing to meet such requirements shall not be reclaimed for sale as food for human consumption or for use in the preparation of such food.

The salvage operation shall be in accordance with standards of sanitation for the handling of food and shall be acceptable to the health officer.

Foods not salvagable shall be disposed of in a manner acceptable to the health officer.

When non-salvaged foods may be safely fed to animals or fowl such feeding shall be permitted as a method of disposal of the material.

Swine Feeding

Permits shall be required in the manner provided hereinbefore.

Investigation shall be made and samples shall be collected as provided hereinbefore.

Records shall be furnished in the manner required hereinbefore.

The following minimum standards shall be required of any swine feeding yard for compliance with the sanitary code in addition to all other applicable requirements:

The feeding platform shall be constructed of concrete and shall be provided with sufficient slope to drain to properly protected catch basins so that the entire platform can be cleaned, bristle broomed, and flushed with water.

All necessary traps, strainers, treatment processes and sanitary safeguards for the discharge of the drainage from such platforms shall be provided so that the sewerage system and discharge shall comply with all applicable provisions of this Code.

No feed shall remain on a feeding platform longer than 24 hours unless it be protected from soil, litter, moisture, water, and foul matter.

Garbage or swill shall be removed at least once in each 24 hour period, and the platform shall be cleaned thoroughly and flushed down before additional material is placed on the feeding platform.

Chapter XXVI

Malaria and Mosquito Control

Although the control of arthropods has been a very important aspect of public health throughout the world for well over a half century, no other arthropod has held the limelight on the American continent with such dramatic eclat than the mosquito: and no arthropod has been so thoroughly studied by scientists and so steadily fought by sanitarians. Although the number of mosquitoes have scarcely been reduced, the amount of disease carried by this vector has been remarkably controlled. This has mainly been due to the knowledge that has accumulated regarding the life-history of so many species of mosquitoes, and the ability of the sanitarian to adapt this knowledge to the practical application of control. This chapter has therefore concerned itself not only with the practical control techniques but also with the life-history and identification of various important species. There are so many variable factors in this control work, that the sanitarian would indeed be lost,or at least inefficient, if he were not armed with the knowledge to know when to change his course of action.

The most important diseases, carried by the mosquito, which are a continual threat in the United States are malaria, yellow fever, dengue fever, equine encephalomyelitis, and St. Louis encephalitis. The last epidemic of yellow fever in this country occurred in 1905 in Louisiana where 9, 321 cases were reported with 988 deaths. Since then this disease has not visited our shores. It apparently first reached this country in the middle of the 17th century and caused about 100, 000 deaths till it was finally exterminated in 1905. Of these deaths 40, 000 occurred in Louisiana. Quarantine measures were mostly responsible for extermination of this disease. Dengue was first recognized in this country in the middle of the 19th century. Although it does not cause many deaths, it is indeed a troublesome disease in those areas where it is prevalent. It occurs mostly in the south and has not penetrated north of Virginia.

Malaria was known very early in medical history, having been already described by Hippocrates about 2500 years ago. Chinese medical works of earlier than 100 B. C. refer to a disease which undoubtedly was malaria. It has been a source of much death and sickness through the tropical and subtropical world. The disease used to be called the "Scourge of the South. " It had been estimated scarcely more than a quarter century ago that 3, 000, 000 cases of malaria occurred in the United States annually. The losses through death, cost of medical treatment, losses to enterprises in malarious regions through inefficient labor and other factors, were estimated to have been at least $100, 000, 000 a year. Since then remarkable control of this disease has taken place. Up to the beginning of World War II, malaria incidence had been gradually declining in the South for a number of years. In the latter 30's the decline was accelerated, probably as the result of increased Federal funds for increasing the application of sanitary measures and the general increase in living standards. When war threatened, the government further increased the funds for sanitary control work. From 1940 to 1951 the reported cases of indigenous malaria decreased well over 90% in the United States. In Louisiana not one indigenous case of malaria has been reported in several years. Quarantine and isolation alone are not effective because malarious people may carry the parasite in their blood for many years. Therefore, adequate treatment of cases and the control of the malaria carrying mosquitoes are necessary for the extermination of this disease.

There are a group of virus diseases known as arthropod-borne encephalitides some of which are transmitted by mosquitoes. The diseases of this group are eastern, western and Venezuelan types of equine encephalomyelitis, St. Louis encephalitis, Russian spring-summer encephalitis, Russian autumn fever, and louping ill. Of these, the various types of equine encephalomyelitis and St. Louis encephalitis are mosquito-borne. The reservoir of these diseases is fowl. The fowl that have been found to harbor these viruses are: pheasants, prairie chickens, pigeons, ducks, geese, domestic chickens, hawks, blackbirds, guinea fowl, sparrows, storks, quail, thrashers, owls, flickers, killdeer, robins, and American egrets. Other animals have been found to be temporary reservoirs of these diseases. Horses and mules appear to be the most important although, experimentally, sheep, goats, dogs, cats and cattle have been infected with the virus.

Equine encephalomyelitis viruses have been found naturally in Culex tarsalis, Culex restuans,

Culex stigmatosoma, Culex pipiens, Aedes dorsalis, Culiseta inornata, Anopheles freeborni, Taeniorhynchus perturbans and several other types of arthropods. Experimental transmission of the disease has been acomplished with Culex tarsalis, Culex pipiens, Aedes aegypti, Aedes triseriatus, Aedes nigromaculis, Aedes atropalpus.

St. Louis encephalitis virus has been found naturally in Aedes dorsalis, Culex tarsalis, and Culex pipiens. It has been transmitted experimentally by Culex tarsalis, Culex pipiens, Aedes lateralis, Aedes taeniorhynchus, Aedes vexans, Aedes nigromaculis, Aedes albopictus.

Japanese "B" encephalitis virus has birds and rodents as the usual hosts and mosquitoes as the usual vector. Louping ill has sheep as the usual host and ticks as the vector, while the usual host of Russian Spring-Summer encephalitis is rodents and the usual vector ticks. Other diseases such as Rift Valley Fever are transmitted by mosquitoes. All diseases of which the mosquito is the vector have as yet not been determined.

Encephalitides Vectors

I. Isolations in Nature

1. Mosquitoes	Western	St. Louis	Eastern	Venezuelan
Anopheles crucians			x	
" freeborni	x			
Culex coronator		x		
" nigripalpus		x	x	
" quinquefasciatus	x	x		
" pipiens	x	x		
" restuans	x			
" salinarius			x	
" spissipes		x		
" stigmatosoma (peus)	x	x		
" taeniopus		x		
" tarsalis	x	x		
" virgultus		x		
Aedes albimanus		x		x
" dorsalis (melanimon)	x	x		
" infirmatus	x		x	
" mitchellae			x	
" nigromaculis	x	x		
" serratus		x		x
" sierrensis	x			
" vexans	x	x	x	
Culiseta incidens		x		
" inornata	x	x		
" melanura	x		x	x
Mansonia perturbans			x	
Psorophora ferox		x		
Sabethes chloroptera		x		
2. Ticks, mites, etc.				
Dermanyssus americanus	x			
" gallinae	x	x	x	
Dermacentor andersoni	x			

	Western	St. Louis	Eastern	Venezuelan
Liponyssus bursa	x			
" sylvanium	x	x		
Triatoma sanguisuga	x			
Biting lice			x	
Culicoides spp.			x	

II. Transmission Experimentally Through Direct Biting

1. Mosquitoes

Anopheles crucians		x	x
" quadrimaculatus	x		x
Aedes aegypti	x	x	x
" albopictus	x		
" atropalpus		x	x
" cantator	x		x
" dorsalis	x		
" lateralis		x	
" nigripalpus	x		
" sollicitans	x		x
" taeniorhynchus	x		x
" togoi		x	
" triseriatus			x
" vexans	x		x
Culex erraticus			x
" nigropalpus		x	
" pipiens		x	
" quinquefasciatus	x	x	x
" salinarius	x		x
" restuans	x		x
" tarsalis	x	x	
" tritaeniorhynchus		x	
Culiseta inornata	x		
" melanura	x		x
Mansonia indubitans	x		
" perturbans			x
Orthopodomyia signifera	x		x
Psorophora discolor	x		x
" confinnis	x		x
" ferox	x		x
" ciliata	x		x
" howardii			x
Toxorhynchites septentrionalis			x

	Western	St. Louis	Eastern	Venezuelan
2. Mites, ticks, etc.				
Dermanyssus gallinae		x	x	
Dermacentor andersoni	x			
" variabilis		x		
Triatoma sanguisuga	x			

III. Laboratory Tests Indicating Estimated Vector Ability

E = excellent vector
G = good vector
F = fair vector
P = poor vector

1. Mosquitoes

Anopheles crucians	P
Aedes aegypti	E
" atropalpus	E to G
" sollicitans	E to G
" triseriatus	E
" vexans	G to F
Culex erraticus	G to F
" nigripalpus	E
" quinquefasciatus	E to P
" restuans	G to F
" salinarius	P to G
" tarsalis	E
Culiseta melanura	E to F
Mansonia indubitans	F to P
" perturbans	G
Orthopodomyia signifera	E to G
Psorophora ciliata	G to F
" confinnis	E to G
" discolor	E to F
" ferox	G to F
" howardii	E to F

Another tropical disease, filariasis, not ordinarily found in the United States is transmitted by a variety of mosquitoes especially Culex quinquefasciatus, and Culex pipiens. There was an endemic area around Charleston, South Carolina but no new cases have been reported in recent years.

Besides carrying diseases, mosquitoes are pests, causing much irritation, loss of sleep and depreciation of land values.

The four most important groups of mosquitoes in the United States which are related to disease carrying are the genera Anopheles, Aedes, Culex and Psorophora.

The Anopheles genus is the malaria carrier. The most dangerous malaria carrying species in this country are Anopheles quadrimaculatus and Anopheles freeborni, the former occurring in South and southeastern states and the latter on the west coast and upper Mississippi valley. Anopheles crucians sometimes carries malaria. Anopheles albimanus is a malaria carrier on the Mexican border. Anopheles walkeri, Anopheles punctipennis, Anopheles atropos and Anopheles barberi do not usually transmit malaria. Of all these, the three most common Anopheles mosquitoes in southeastern United States are Anopheles punctipennis, Anopheles quadrimaculatus and Anopheles crucians. The Anopheles mosquitoes are the only vectors of malaria.

The known malaria-carrying mosquitoes for other continental areas are:

Central America: A. albimanus, A. aquasalis, A. punctimacula, A. darlingi, and A. aztecus.

South America: A. albimanus, A. aquasalis, A. bellator, A. cruzi, A. darlingi, A. pseudopunctipennis.

Europe: A. labranchiae atroparvus, A. claviger, A. hispaniola, A. labranchiae, A. maculipennis messeae, A. sacharovi, A. superpictus, A. pattoni, A. sinensis.

Africa: A. pharoensis, A. sergentii, A. multicolor, A. hispaniola, A. gambiae, A. funestus, A. rufipes, A. moucheti, A. brunnipes, A. hancocki, A. hargreavesi, A. nili, A. dthali.

Asia: A. culicifacies, A. stephensi, A. fluviatilis, A. annularis, A. varuna, A. philippinensis, A. minimus, A. leucosphyrus, A. maculatus, A. sinensis, A. pattoni, A. sacharovi.

Malaysia: A. balabacensis, A. sundaicus, A. maculatus, A. sinensis, A. umbrosus, A. aconitus, A. minimus flavirostris, A. philippinensis, A. barbirostris.

Australia, New Guinea, and surrounding islands: A. kolienis, A. punctulatus, A. farauti, A. annulipes, A. bancroftii, A. subpictus, A. amictus.

It was once thought that the species Aedes aegypti was the only one which carried yellow fever. But in the jungles of Brazil and Africa, yellow fever has been found in epidemic form although not associated with Aedes aegypti. This is called "jungle fever". In Brazil, it has been found that some other mosquitoes, especially the genus Haemagogus, may harbor the yellow fever virus and transmit it. On both continents, it seems that monkeys serve as a reservoir. Aedes triseriatus which is a very common mosquito appears to be able sometimes to transmit this disease from animal to animal. The mosquitoes of the genus Aedes which are commonly found in southeastern United States are Aedes aegypti, Aedes vexans, Aedes sollicitans, Aedes taeniorhynchus, Aedes triseriatus, Aedes atlanticus, Aedes canadensis, Aedes dupreei, Aedes infirmatus and Aedes thibaulti. In Africa, the vectors are Aedes africanus and Aedes simpsoni.

Dengue fever is found in the southern part of this country and is transmitted by Aedes aegypti. It is suspected that Culex quinquefasciatus and possibly other mosquitoes may transmit this disease.

The common species of the genus culex that are found in southeastern United States are Culex quinquefasciatus, Culex restuans, Culex salinarius, Culex apicalis and Culex erraticus.

Several other smaller groups of mosquitoes but yet fairly common in southeastern United States are the genera Uranotaenia, Psorophora, Mansonia, and Culiseta.

The common species of these four genera in southeastern United States are Uranotaenia sapphirinus, Psorophora columbiae, Psorophora ciliata, Psorophora ferox, Psorophora howardii,

Psorophora cyanescens, Psorophora varipes, Mansonia perturbans and Culiseta inornata.

Basic Habits of Some Important Species of Mosquitoes in the United States.

Breeding Habits and Distribution

Anopheles - The following thirteen species of Anopheles are extant in the United States. Most of these have proved to be susceptible to malaria infection by experiment and two of them have been infected with malaria parasites under natural conditions and are natural vectors of malaria.

It can generally be stated that the Anopheles have a preference for clean, stagnant water with vegetation. But it is by no means a rarity to find them breeding in artificial containers, in muddy, dirty, and polluted water and in a wide range of other breeding places. Therefore, it must be understood that, although, the following discussion outlines the most important perferences for certain Anopheles mosquitoes, it by no means intends to convey the idea that they may not breed at times in a host of other environments.

In the United States, malaria control by anti-mosquito measures should be directed principally against Anopheles quadrimaculatus and Anopheles freeborni, the two most important malaria carriers in this country.

The thirteen anopheles are divided into four groups in accordance to the spots on their wings, which characteristic is used in identifying them. Group I has one pale area at the top of the wing. Group II has two pale areas on the upper outer margin of the wings. Group III has unspotted wings. Group IV has four black spots on the wings.

Group I

Anopheles crucians occurs principally in the coastal region of the United States from Massachusetts southwest to Kansas, Oklahoma and Texas, and in the lower Mississippi Valley. This is the common fresh-water anopheles of the southeastern states.

Anopheles georgianus has been reported from all the southeastern states except Tennessee and Arkansas. Its typical habitat seems to be seepage areas at the head of small streams.

Anopheles bradleyi occurs along the Atlanta and gulf coasts from Maryland to Mexico. Normally it breeds only in brackish water near the coast. Water of a low concentration of salt, about 1.5 percent or less, seems to be preferred.

Group II

Anopheles punctipennis occurs in Southern Canada and throughout the United States but rarely in the Rockies between Canada and New Mexico. It breeds chiefly in clean water such as streams, stream-fed pools, and the more permanent rainwater pools. This species appears to be the only one of the North American Anopheles that is commonly found in streams.

Anopheles albimanus appears to be found only in the lower Rio Grande Valley of Texas and nowhere in the United States. It is, however, a very important malaria carrier in tropical America. Its breeding habits in the United States have not been well worked out.

Anopheles franciscanus resembles Anopheles pseudopunctipennis very closely. This species has been collected from the southwestern part of the United States.

Anopheles pseudopunctipennis has been found in Oklahoma and Eastern Texas, and on occasions in bordering states. It breeds in wayside sunlit pools especially the semi-permanent ones left by seasonal rains in semi-arid country.

Group III

Anopheles atropos breeds in brackish or salt-water pools along the Gulf of Mexico and Atlantic coast from Maryland to Texas. The larvae have been found in grassy or algae-filled pools, in the alluvial marshes, in shallow waters and in muck.

Anopheles barberi occurs throughout the southeastern part of the United States, but is extremely rare. It breeds usually in water in tree holes, but occasionally in artificial containers in

shady places from New York southward and westward to Texas, and north to Iowa. It has been found in all Southeastern States.

Group IV

Anopheles quadrimaculatus is the important malaria transmitter in the South and Southeast and is usually termed a "Pond Breeder," as it is rarely found in flowing water. It frequents permanent bodies of water usually well grown up with vegetation, such as fresh water pools, ponds, shallow lakes, rice fields, borrow-pits, lake margins and ponded swamps. It apparently prefers neutral or slightly alkaline water rather than acid water. There is considerably evidence that the range of types of places used by this mosquito is the widest of all anopheles. Any place in which any anopheles is breeding in Louisiana except possibly Anopheles barberi may be considered a potential breeding place for Anopheles quadrimaculatus.

Anopheles occidentalis seldom occurs in large numbers except at very localized points. It is found in the Pacific Coast states in a narrow strip along the coast. Its range extends across the northern part of the United States to Maine, south to Connecticut, central New York, west through Michigan to Iowa and Nebraska. It breeds along the grassy margins of lakes, in slow moving streams containing vegetation, and in similar situations. The larvae may sometimes be found in hoof prints of animals and in small depressions along little streams.

Anopheles freeborni cannot be distinguished from Anopheles quadrimaculatus in the adult stage. In general, specimens from east of the Rocky Mountains are Anopheles quadrimaculatus, while those from west of the Rockies are Anopheles freeborni. The ranges of these two are not known to overlap.

Anopheles walkeri is widely distributed in North America. Its range extends from central Ontario south through the eastern United States to the Gulf of Mexico, west to western Louisiana and north to Minnesota. The species seems to be more common than collections would indicate. Its breeding places, shelters, and resting places are usually difficult to locate. Specimens have been found in barns, piggeries, and under houses, but they seem to prefer to remain in the emergent vegetation grass and shrubbery near their breeding places. Adults are attracted readily to light traps. It has been found in water covered by water-hyacinths (Mississippi), in cattail marshes (New York and Florida), and in rice fields (Arkansas).

The discovery that Anopheles maculipennis is composed of several races of mosquitoes, two of which have been named Anopheles occidentalis, and Anopheles freeborni, has rendered the term Anopheles maculipennis obsolete.

For the breeding habits and distribution of other genera of mosquitoes found in the United States see Chart 1

Seasonal Breeding.

Anopheles. There seems to be some evidence of a seasonal rotation of Anopheles species in that A. punctipennis is the earliest on the wing in great numbers, with A. crucians coming second, but disappearing in hot weather, while A. quadrimaculatus appears latest and seems to persist through the summer. In the fall the above order appears to be reversed. Generally considered, Anopheles are heaviest in summer, but fairly heavy in spring and fall, and even during prolonged warm spells in winter. This pattern fits the Anopheles in the far west.

Aedes aegypti is usually important only in warm weather, but may breed inside warm buildings in cold weather. A. vexans is an early spring species in the south. A. triseriatus is an almost year round breeder. Most of the Aedes will breed in the warm season and not in very cold weather. Some of the species show a great tendency to produce in one enormous brood each spring of the year.

Culex quinquefasciatus breeds most intensely in summer, but also in cool weather and not in coldest weather. The same holds true for most culex species. Culex apicalis has a peak production in cold weather, persisting through the cold seasons. Culex restuans tends to a peak production in cool weather.

Psorophora. These breed largely from early May through the cool season. Psorophora varipes is a one brood species appearing in the spring. Psorophora cyanescens produces in hot weather only. Most Psorophora have their peak production in hot weather.

Mansonia perturbans. They are present from March to December with peaks in May and August-September with only desultory production during the rest of the year.

Flight Range

Anopheles. A knowledge of the distance of flight of the various species of Anopheles that convey malaria is of great importance in control operations. It is generally considered now that the flight range of these mosquitoes is not more than a mile, therefore, control of production within a radius of about 1 mile will ordinarily protect the human population from malaria. A. quadrimaculatus may have a flight of almost 2 miles, while A. albimanus may have a flight range of 1 1/4 miles.

For flight range of other genera of mosquitoes see Chart 1

Length of Stages Necessarily Spent in Water

Anopheles, Culex, and most of Aedes remain in their water stages at least 8 to 10 days, but this varies according to temperature and other conditions. Psorophora have aquatic life stages usually of 3 or 4 days. Mansonia have, it is believed, long aquatic life of 3 or more months, remaining over winter in many instances.

Biting and Other Habits.

Anopheles. A punctipennis bites on porches after dusk and is often found underneath occupied houses. A. quadrimaculatus, and sometimes A. crucians, will enter houses freely, the former after dusk while the latter will bite at any time of the day even in direct sunlight. The Anopheles bites are usually not very annoying, and the peak of biting is at dusk. A.quadrimaculatus will also bite in the shade during the day and sometime in sunlight.

For the biting habits of other genera of mosquitoes see Chart 1

Day Resting Places.

Anopheles are usually found resting in the daytime in dark or semi-dark places which are cool, humid, and out of reach of strong air currents. The daytime resting to which the attention of collectors should be directed are:

1) Inside houses, especially the sleeping rooms and porches.
2) Beneath elevated dwellings and other buildings.
3) In stables and other shelters for domestic animals.
4) In privies.
5) Under bridges and in culverts.
6) On the shadyside of road-cuts and the like.
7) In the interior of hollow trees.
8) In boxes and in barrels under shelter.

Aedes aegypti is found in and near habitations. Most Aedes are found near their breeding areas.

The various Culex groups are found more or less in the same places as Anopheles.

Psorophora are found in proximity of breeding areas.

Mansonia perturbans is found resting in shady, moist places, but its daytime resting places are difficult to find except by being bitten.

Life Cycle of the Mosquito.

There are four stages in the development of mosquitoes: The eggs, the larvae or "wigglers," the pupae, and the adults. According to the species of mosquito, the eggs are layed on the surface of the water, at the edge of the water, on the wet mud, or on the dry mud. The shape of the egg also depends upon the type of mosquito. The Culex egg is usually oval shape and clustered

together in the form of a raft which floats on the surface of the water. The Aedes eggs are elongated ovals laid singly on damp soil at edge of water or in moist depressions. Some Aedes may lay eggs on the water surface. The Anopheles eggs are shaped like boats with air chambers on each side. They are layed singly. Some types of mosquitoes may lay their eggs in small dry depressions in the ground where they may remain all winter and, in spring, hatch out when coming in contact with water. Those eggs which are so layed remain viable in the dry state for five years.

The larva hatches from the egg and must have a watery environment in order to live, grow and develop. This stage feeds on protozoa, algae, decomposed organic matter, bacteria and colloids. Some feed at the surface of the water, such as Anopheles; others, the Culex and Aedes, feed below the surface. Larvae have breathing apparatus at the lower end of their abdomen. All larvae except Anopheles have well developed breathing tubes. All larvae pierce the surface film of water with their breathing tubes to obtain atmospheric air except Mansonia which obtains its air from plant roots by means of a saw-tooth breathing apparatus. Larvae moult or shed their skins 4 times - the fourth moult changes the larvae into pupae. Larvae may remain in the water or in ice over winter. The larval period is from several days to several months, depending upon the species and the temperature.

The pupal period lasts on an average of 2 days. It does not moult nor can it remain in the water or ice over the winter. This is also an aquatic stage. It cannot live, grow, or develop without a water environment. The adult developes from the pupa. Under favorable conditions the usual life period of the house mosquito in mid-summer is about 2 or 3 weeks, but this may vary widely with changing conditions. Some mosquitoes may hibernate in the fall and live to the following spring.

Suggestive Association of Mosquitoes Grouped According to Typical Larval Habitats.

Artificial Containers: Aedes aegypti, Aedes triseriatus, Culex quinquefasciatus, Culex restuans, Culex salinarius, Culex apicalis (seldom).

Permanent Pools: Anopheles quadrimaculatus, Anopleles crucians, Culex apicalis, Culex erraticus, Cules salinarius, Culex restuans, Mansonia perturbans, Uranotaenia sapphirinus.

Temporary Rain Water Pools: Psorophora ciliata, Psorophora columbiae, Psorophora ferox, Psorophora howardi, Psorophora cyanescens, Psorophora varipes, Aedes vexans, Aedes sollicitans, Aedes taeniorhynchus, Aedes atlanticus, Aedes canadensis, Aedes dupreei, Aedes infirmatus, Aedes thibaulti.

Salt Marshes and Brackish Water: Aedes taeniorhynchus, Aedes sollicitans, Anopheles Atropos, Anopheles crucians.

Water Covered with Water-Hyacinths, Cattail Marshes: Anopheles walkeri, Mansonia perturbans.

Irrigation Water (including Seepage): Anopheles freeborni, Anopheles georgianus.

Rice Fields: Anopheles freeborni, Anopheles quadrimaculatus, Anopheles walkeri.

Flood Waters, and Open Swamp Pools: Aedes vexans.

Streams: Anopheles punctipennis, Anopheles occidentalis.

Tree Holes: Aedes triseriatus, Anopheles barberi, Orthopodomyia signifera.

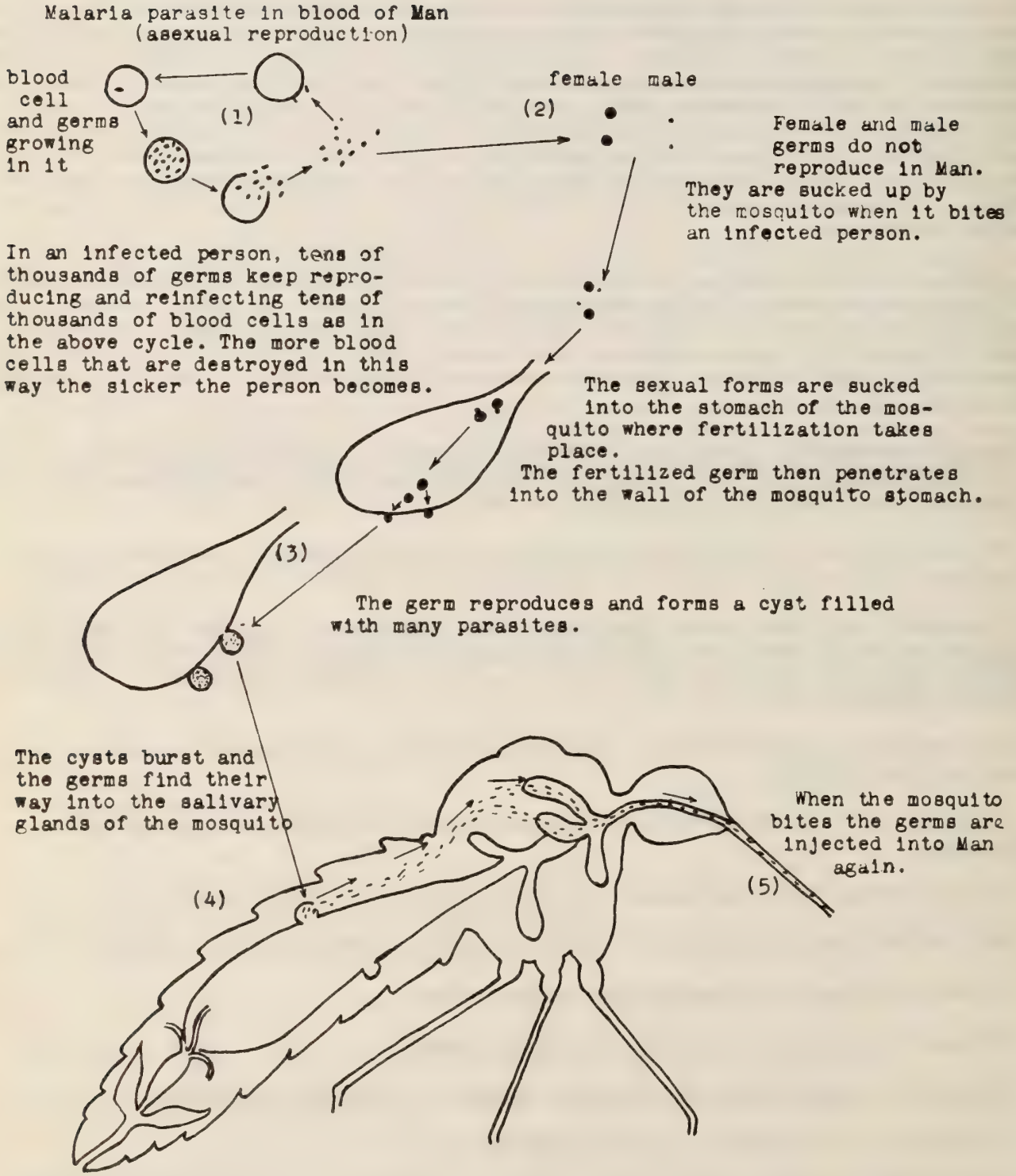
Cesspools and Open Sewers: Culex quinquefasciatus.

Woodland Pools: Aedes vexans, Aedes atlanticus, Psorophora ferox, Psorophora varipes, Mansonia perturbans, most other Psorophora and Aedes.

It must be noted that there is scarcely any such classification as "typical breeding places"

Chart 2

Life Cycle of the Malaria Parasite


Malaria parasite in blood of Man
(asexual reproduction)
blood cell and germs growing in it
(1)
female
male
(2)
Female and male germs do not reproduce in Man. They are sucked up by the mosquito when it bites an infected person.
In an infected person, tens of thousands of germs keep reproducing and reinfecting tens of thousands of blood cells as in the above cycle. The more blood cells that are destroyed in this way the sicker the person becomes.
The sexual forms are sucked into the stomach of the mosquito where fertilization takes place.
The fertilized germ then penetrates into the wall of the mosquito stomach.
(3)
The germ reproduces and forms a cyst filled with many parasites.
The cysts burst and the germs find their way into the salivary glands of the mosquito
(4)
(5)
When the mosquito bites the germs are injected into Man again.

for mosquitoes except possibly in a very general way, since there is a great deal of "atypical" breeding among mosquitoes. It is therefore necessary to remember that the above classification of breeding places is not to be considered too faithfully lest failure and confusion follow. It is merely given as a general starting point and it is expected that the sanitarian be constantly aware of variations.

Life Cycle of Malaria Parasite

Malaria infected mosquitoes infect persons by biting them. Infected persons carry malaria parasites in their blood. The parasites live, nourish, grow, and reproduce in the red blood cells. (See (1) in Chart 2. After a parasite invades a red blood cell it reproduces many parasites without going thru any noticeable sexual activity. This is known as the asexual phase of the malaria parasite development. When the red blood cells become filled up with these asexual parasites, they burst and release the parasites into the blood stream. Each new parasite seeks a new blood cell to invade in which it may be able to grow and reproduce again. So the process continues until most of the red blood cells have been destroyed and the person either dies or the body has been able to develop enough resistance with or without the aid of medicine that the parasites are destroyed or controlled. The asexual phase of malaria parasite reproduction is called "schizogony."

At the same time that the asexual cycle is going on, a certain number of sexually differentiated parasites develop in the blood, but these do not reproduce while in the human body. See (2) in Chart 2. They remain inactive until a mosquito comes along and sucks them into its own body. These sexual forms can reproduce only in the body of the mosquito. From the time a person is bitten and injected with malaria parasites, it takes about 2 weeks for enough parasites to develop in the blood of the human in order to cause symptoms of sickness in the infected person.

After a female anopheles mosquito takes a blood meal from an infected person and sucks up some of the sexually differentiated germs, these sexual forms reach the stomach of the mosquito and fertilization takes place. The fertilized parasite bores into the stomach wall of the mosquito and begins to grow and develop a brood of new parasites. See (3) in Chart 2. The cyst in which this growth and reproduction takes place becomes larger and larger until it bursts and the new parasites (sporozoites) are released into the body cavity of the mosquito. See (4) in Chart 2. The parasites then ply their way forward to the salivary glands into which they bore and bathe in the saliva of the mosquito. When the mosquito bites a person it injects some of its saliva into the skin of the person to prevent his blood from clotting. At the same time the parasites are also injected into the tissues of the person, from which site they gain access to the blood where they begin to reproduce again as shown in (1) of Chart 2. Thus the cycle is completed and begins all over again. The sexual phase of malaria parasite reproduction is called "sporogony." It takes about 8 to 10 days for the completion of the sexual cycle of the parasite in the female mosquito.

It may be noted here that such animals as birds and monkeys may also become infected with malaria, but in each case the germs are specific for each type animal, that is, specific types of malaria germs infect specific types of animals. The germs which infect man will infect no other animal. The germs which infect birds will not infect man or monkey, and so on. This principle of specificity must not be taken too categorically, since there is growing evidence that some species of malaria germs can be transmitted both to man and certain animals.

Classification of Mosquito Abatement Methods

The following classification is given for the purpose of acquainting the sanitarian with the fact that the methods of mosquito abatement are numerous and in a number of instances very technical, requiring good engineering skill. It is good to realize that all phases of sanitary science has much complicated background even in cases where methods are apparently simple. The classification should stimulate the sanitarian to study further and acquaint himself with the details, as far as it is possible, of the extensive field of mosquito control.

Against Aquatic Stages

I. Mechanical
- A) Drainage:
  - 1) Open
  - 2) Subsurface
  - 3) Vertical
- B) Pumping:
  - 1) Surface waters
  - 2) Subsurface (well) water
- C) Diversion of water
- D) Channeling of streams and sloughs
- E) Filling in low areas
- F) Restriction or control of excessive use or needless abuse of irrigation water
- G) Diking and dewatering

Miscellaneous:
- 1) Screening or mosquito-proofing cisterns, wells and water containers
- 2) Removal or destruction of unnecessary artificial water containers
- 3) Removal of protective vegetation or floatage.
- 4) Repair of leaks or defects in water supply, plumbing or drainage systems.
- 5) Tree surgery

II. Chemical:
Aquatic plant destruction, ex., 2, 4-D

III. Toxic Larvicides
- A) DDT and other chlorinated hydrocarbons
- B) Other new larvicides
- C) Petroleum derivative oils
- D) Paris green and other chemicals

IV. Naturalistic
- A) Chemical
  - 1) Changing salt (NaCl) content of water: Salinification
    Freshening
  - 2) Pollution: With decaying vegetation, or with sewage or wastes
  - 3) Stagnating
- B) Physical
  - 1) Drying by agricultural use or by special planting
  - 2) Natural fills (silting)
  - 3) Flooding: Controlled reflooding and redraining
  - 4) Setting water in motion
  - 5) Intermittent drying
  - 6) Fluctuating water levels
  - 7) Flushing or sluicing

Against Adult Mosquitoes

I. Mechanical
- A) Screens
  - 1) Nets
  - 2) Special Clothing
- B) Deterrents
  - 1) Fans
  - 2) Exposure to wind
- C) Trapping:
  - 1) Baited traps
  - 2) Light traps
- D) Hand catching and killing
  - 1) Active season killing
  - 2) Winter killing
- E) Removal of houses or villages to sites beyond flight range

III. Toxic
- A) Residual sprays
- B) Pyrethrins
- C) Fumigants
- D) Chemical repellants

IV. Naturalistic
- A) Chemical
  Creating repellant carriers of odorous plants.
- B) Physical
  - 1) Clearing, destruction, or removal of shelter
  - 2) Creation of plant barriers to flight.
  - 3) Rendering dwellings, especially bedrooms, unattractive to mosquitoes.

8) Agitation of water surface
9) Shading to exclude sunlight
10) Clearing to expose to sunlight
11) Muddying

C) Biological
1) Introduction of natural enemies: Predatory fish; Other aquatic predators
2) Changing flora and fauna to unsuitable or competitive types
3) Elimination or destruction of aquatic food supplies

C) Biological
1) Introduction of natural enemies: Predatory crepuscular birds, etc. Parasites
2) Interposing animal habitation between breeding places and human abodes
3) Minimizing available harborage for winter hibernation

Fundamentals of Mosquito Abatement

Considering the great diversity in types of breeding places, types of food preferred, flight habits, ability to transmit disease, and economic effect of the various species of mosquitoes, we begin to realize the complexity of the problem of control. Generalized rules of thumb are not to be too closely followed, but certain definite simple rules can be applied by the sanitarian with rather good results in instances where the problem is not too extensive or complex. Success in mosquito abatement depends upon exact knowledge of the species of mosquitoes in the particular region to be placed under control, of the habits of each particular species or sub-species, and of the appropriate methods for abatement of each species.

Up to the time of discovery of DDT, screening, frequent spraying, and use of repellants was a difficult and certainly a tedious method of adult mosquito control. This method was therefore not considered a primary activity for large scale, permanent control, but only an accessory method and one used in emergency situations and in undeveloped areas. Larva control by mechanical, naturalistic, and toxic larviciding procedures was the primary method of controlling mosquitoes. DDT has, to a large extent, changed the relation of the above primary and accessory methods of control. The reasons for the change are that DDT and other synthetic insecticides:

1) Are cheaper than other mosquito poisons.
2) Have the property of leaving residual toxicity that may last for months when sprayed on surfaces.
3) Can be applied to surfaces without staining or streaking.
4) Are effective killers of the adult as well as the larval forms.
5) Are excellent means for rapid elimination of diseases carried by mosquitoes.

Because it can be used so effectively against the adult mosquito, adulticiding or imagociding has come into prominence as a primary method in preventing and controlling diseases carried by the mosquito. This change of emphasis may even become greater when newer chemicals with greater toxicity and less resistance-producing quality for the mosquito are discovered having greater ability to produce residual toxicity and being low in toxicity for man and animals.

A word of caution: lest we go to extremes and forget the importance of the permanent control methods effected by mechanical and naturalistic practices, permanent large scale mosquito control must utilize all proven methods that reduce larval and adult populations most effectively and economically in long-time programs. Over a long period, the mechanical and naturalistic methods are cheap and effective, do not exact tedious detailed attention to individual abodes, and do not contribute to dangerous pollution of our streams and soil as do the newer chemical usages.

There are certain pit-falls which must be kept in mind in the development of techniques which produce modifications in the natural environment. The most important to remember is that, in the struggle for survival among all living organisms in the natural state, a balance developes between the organisms and their environment which helps them survive the forces which would completely destroy them. For example: The number of mosquitoes in various areas would multiply to an unbearable extent, so far as humans are concerned, if certain aspects of the physical environment became so favorable that all mosquito eggs developed into adults, or if certain mosquito larva predators such as Dytiscid beetle larva and the "back swimmer" would not be present to destroy the mosquito larvae. DDT kills not only the mosquito larvae, but also the above

mentioned and other predators of the mosquito larvae. Then, after the affect of the DDT has disappeared, the mosquito population may multiply to a much greater extent than before the larvicide technique was used, since the natural predators had been diminished. Therefore, a continuation of larviciding is important to maintain mosquito control. The lesson is, that every control measure, because it upsets some phase of natural balance, bears within it the seeds of an opposite outcome. It is this that must be closely watched. And it is for this reason that the use of DDT and other techniques, which upset natural balances, should be strictly supervised by experts.

Attention is directed to the use of naturalistic control methods which aim to effect simple changes in environment to make it unsuitable for the breeding of the particular species in that region. The naturalistic methods are in most instances of an engineering nature and require highly skilled personnel as directors of the work. There is evidence that these methods will in the future become more used and developed, since they lend themselves to large scale projects for mosquito control. There is little doubt that the future will see mosquito control projects whose magnitude is today scarcely imaginable. Let it be understood that naturalistic methods are still in the experimental stage, but that they hold the most promising solution for permanent large scale mosquito control. In the presence of a mosquito transmitted disease a selective attack (species sanitation) against the vector species is of primary importance, especially where limited funds make it impractical to attempt a program for the abatement of all types of mosquito breeding.

Ideally, reducing the production of mosquitoes is principally a matter of reducing, safeguarding, or eliminating the water in which mosquitoes breed, or by appropriate naturalistic methods, rendering such water unsuitable for mosquito breeding. If, after this has been accomplished to the greatest practical extent, there still remains some mosquito breeding, then this residual production must be controlled by supplemental measures. But the use of larvicides for the destruction of the aquatic stages of mosquito life must always be looked upon as an accessory method of mosquito elimination, the necessity for which should be reduced to a minimum by the primary methods of drainage, filling, constant level flooding, controlled reflooding, and other such methods. But these accessory methods are by force of necessity, still being used as primary methods due to purely economic reasons and needs for rapid disease elimination. There are so many communities in our country which are too poor to make an outlay of money at one time that would be sufficient to carry on a control program by the primary methods. But the fact remains that we are not far off from the day when the primary methods will be used for permanent control.

Perfection of detail and continuity of effort are important in effective control work. A sustained attack, year after year will produce better ultimate results than in intense attack in one year followed by comparative neglect and inaction.

Preliminaries to Abatement Procedures

Before any mosquito abatement project is begun, it must be planned and organized. The proper personnel should be engaged and adequate equipment and supplies provided. This is the ideal and logical method of procedure. But in the "rough and ready" activity of every-day work, where adequate personnel and money are usually lacking, and where emergencies arise that require immediate action, these preliminaries are by-passed and the work is begun on a more or less trial and error basis, relying on the effectiveness of the old stand-by cure-all methods of oiling, spraying and ditching. And it cannot be gainsaid that these methods will in a good number of instances give results if correctly carried on. It would be folly to disregard preliminary planning in large scale mosquito control projects.

The preliminary report should include data and recommendations on the following matters:

1) The boundaries of the region which should be included within the project.
2) Population, area, and assessed valuation of the region.
3) Location and area of the principal breeding places.
4) Tentative suggestions as to the best methods of control for each principal breeding area.
5) The species of mosquitoes involved, with a brief discussion of their breeding habits.
6) The amount and types of domestic mosquito breeding within the region, and measures for abatement.
7) The probable organization that would be required, including personnel and equipment.
8) Detailed preliminary estimate of cost, both for permanent work and for regular

maintenance; and comparative costs for areas of similar size and conditions.

9) The economic losses caused by mosquitoes in the area, and the economic savings which would result from adequate abatement measures.

Methods of Abatement

Drainage and Filling

The Aim: (a) To direct all excess storm water into ditches within a day or two following rains, (b) to prevent the formation of any ponds, pools or puddles from remaining more than a day or two following rains, (c) to remove all water from the area to be protected within seven days following a rain, (d) and to accomplish the above in a practical and economical manner. Where the aim cannot be achieved completely, it is necessary to attempt to reduce the breeding areas to the point where other control measures may be feasibly supplemented.

Antimosquito drainage may be accomplished by means of surface ditches of either the unlined, lined, or rock filled type, or by subsurface tile drains.

In planning a drainage system, consideration should be given to the probable period during which the ditches will contain water and to the best location of the ditches or tile lines with regard to grade and the type of soil. Careful planning for, and supervision of, the construction of a drainage system will increase its effectiveness and reduce the cost of maintenance.

In many instances it will be found desirable to make a map or sketch of the area to be drained, showing the location and available grade of at least the main ditches or subsurface drains.

Open ditches: In order to prevent mosquito breeding in the water in ditches, open ditches should be so constructed that standing water will be completely removed and storm water drained from the surface of the ground and from ditches within a short time after a storm. The grade and width of the ditches should be such that while all water will be carried away, the velocity will not be sufficient to produce "potholes" by erosion of the bottom or sides of unlined ditches. Such potholes may contain water long after the remainder of the ditch is dry and constitute places for prolific mosquito breeding. A ditch that is too wide or too flat may likewise retain water in small depressions and thus defeat the purpose of drainage. Unless guarded against by frequent and careful inspection during construction, portions of the ditch may be excavated below or above the established grade, producing either low areas which will retain water when the rest of the ditch is dry or high sections which will prevent complete drainage.

Only a sufficient number of ditches should be dug to accomplish the desired purpose, that is, the removal of standing water or the prompt elimination of storm water. Too few ditches will fail to attain these objectives while too many will increase the cost of construction and maintenance.

Generally, all ditches should be constructed with narrow bottoms, smooth sloping sides, with as few curves as possible, and without sharp turns. Usually the sides of the ditches should have a slope of about 45° although in soft mud or sand the slope should be flatter, while in rock or clay the sides may be nearly perpendicular. If ditches be built at an angle to the slope of a hill, the upper side should be somewhat flatter than the lower in order to lessen erosion. The bottom of all ditches should be U-shaped, not V-shaped, and in the case of wide ditches the bottom should slope toward the center even if the sides be vertical. As far as practical all vegetation which would shelter the adult mosquito should be removed from the edges of the ditches.

The main ditch should be constructed first and laterals installed only when and where they are necessary. At times it may be expedient to wait until after a storm or heavy shower to determine the number and location of additional or lateral ditches. A lateral or branch ditch should join the main ditch at an acute angle or gentle curve in order to avoid the deposition of debris or silt at the junction, or to prevent erosion of the opposite bank and the formation of holes in which water may be retained.

Care should be exercised that the dirt thrown out in digging the ditch does not form spoil banks which, by preventing the drainage of surface water into the ditch, will create pools and puddles in which mosquitoes will breed. Where the ditch runs transversely to the slope of the ground, the

excavated dirt should be placed on the downhill side. Where necessary, spoil banks should be leveled or the dirt disposed of elsewhere.

Where the ditch goes through a culvert or wherever a pipe section is installed, the grade should be increased to prevent interference with the flow of deposits of debris. At the downstream end of the pipe or culvert, the bottom of the ditch should be lined with stone or concrete for a distance sufficient to prevent erosion and the formation of a hole in the bottom of the ditch. The upper end of the pipe or culvert may, if necessary, be screened with iron rods or a wooden grating to prevent the entrance of large pieces of debris or floatage.

Dynamite may be used to an advantage in wet ground in the construction of large ditches of considerable length where there is sufficient fall and volume of flow to permit of irregularities in grade. This method is most suitable for ditching swamps and marshes where the soil is water-soaked and where there are many surface and subsurface obstructions, such as roots and brush.

Dynamite cartridges are placed in holes made in the ground with an iron bar or a wooden pole. The size of the dynamite charge and the spacing and depth of the holes depend upon the width and depth of the desired ditch and the nature of the ground, and are usually determined by trial shots. In the construction of the ordinary ditch the charges are placed about 24 inches apart and at a depth of about 24 inches. Usually a section 100 or more feet in length is excavated at one firing. It is usually necessary to smooth the walls and bottom sufficiently to remove the high and low spots which would cause the formation of pools.

Ditch digging with dynamite, where practicable, is rapid and economical, and has the further advantage that the dirt which would otherwise form spoil banks is distributed over the terrain. It is not a feasible method for use in dry soils or in the construction of small ditches or those which must be carefully graded.

Lined Ditches. Where an open dirt ditch is in loose soil or where the flow in such a ditch reaches a high velocity, the bottom and sides may be rapidly eroded, increasing the difficulty and cost of maintenance and decreasing the effectiveness of the ditch in preventing mosquito breeding. Under these circumstances it may be found advisable to line the ditch with some impervious material for the purpose of preventing erosion of the sides and bottom or caving of the banks. A well-constructed lining also facilitates cleaning. (See Figs. 1 and 2.)

Ditches may be lines with concrete or with stones laid in mortar, preferably cement mortar. Usually a lining which covers the bottom and extends up the sides to about three inches above the normal water line will suffice and it is not necessary to extend the lining to the top of the ditch walls. At other times, only the curves, turns, and junctions need be lined.

Fig. 1

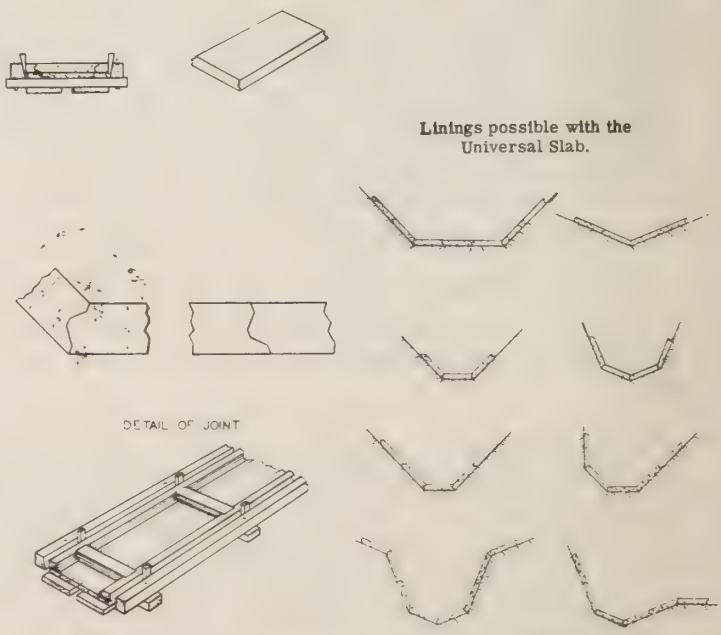


Fig. 2

The forms are left in place for approximately 24 hours; then the side rails may be removed, the slabs and partition form members remaining undisturbed on the pallet or platform for a minimum time of 48 hours.

At sharp curves the lining of the outer wall should be raised high enough to prevent scouring by an overflow of storm water. Also where the current from a branch ditch strikes the opposite side of the main ditch, the ditch lining may be raised or a splash wall installed to prevent erosion of the earth and the formation of potholes.

If stones be used for lining, fairly large flat stones should be selected for this purpose. The interspaces should be filled with smaller pieces and the hole sealed with cement mortar.

Subsurface drainage. Subsurface or subsoil drainage lines consisting of covered tiles or rock filled ditches may be used to drain away surface water as it is absorbed into the ground, to lower the level of the ground water so that the soil will more readily absorb the surface water, or to intercept seepage planes and prevent seepage water from forming pools on the surface of the ground.

Tile drainage. The tiling used varies in size from 3 to 12 inches, usually from 4 to 6 inches, in diameter. The lines are laid in the general direction of the grade and from 50 to 150 feet apart. The average depth of the tiling is from 2 to 4 inches below the surface, but the depth at which the tile is laid and the distance between lines will vary according to the topography and other local conditions. The closer a subsurface drain is to the surface of the ground, the more rapidly it will drain away the surface water and the smaller the area which it will drain.

The tiles are laid in the bottom of a carefully graded trench the slope of which should be not less than 3 inches per 100 feet. The trench is back filled and the tiling covered with earth, gravel or graded rock. Gravel or graded rock filling facilitates the rapid removal of storm water. If graded rock be used, the larger sizes are placed in the bottom of the ditch around the tiles and the finer grades at the top. The filling should be carried to a height of several inches above the level of the ground.

Rock-filled ditches without tiling. Subsurface drainage may be accomplished by trenches back filled with graded rock, or relatively large stones but without tiling. The trenches are usually dug from 12 to 24 inches in depth and the width of the spade or shovel used in digging. The rock used for filling should be from 2 to 6 inches in diameter and, if graded, the larger sizes should be placed on the bottom.

Rock-filled ditches of this type are suitable for draining away slowly accumulating collections of water such as are found in spring-fed marshes. Cost of maintenance is low as the rock filling prevents erosion and caving of the ditch walls.

Double decker drains. The so-called "double decker" drain has been of value in draining areas where there is a flow of water at all times but where the volume of water during the wet season is too great to be carried by the ordinary tile drains. The double decker drain consists of a ditch on the bottom of which 6 or 8 inch tile is laid in the usual manner. Instead of completely back-filling the ditch, ordinary sectional, concrete ditch linings are laid on top of, or immediately above the tiling. The dry weather flow is carried by the tile line while the wet weather flow is drained away through both the tile line and the super-imposed open, concrete lined ditch.

Intercepting drains. Occasionally subsurface tile lines are installed for the purpose of intercepting the flow of seepage water. Seepage water is ground water (spring water) which is forced to the surface of the ground by the position of the underlying impervious stratum. Seepage areas usually occur on the side of a hill but may be found in other localities. The seepage water usually collects in small pools or puddles or produces a marshy area in which mosquitoes may breed in large numbers. An intercepting drain which consists of a tile line covered with graded rock is laid at approximately right angles to the direction of flow of the seepage water. It should be located above the point of the maximum flow of the seepage outcrop as determined by inspection during or soon after a heavy rain.

Maintenance of subsurface drains. Well constructed subsurface drains require but little attention, although occasional inspections should be made for clogging. It may be necessary to provide protection where traffic passes over a tile line. Ordinarily no cleaning or regrading is required.

Resume of principles of drainage to be followed:

a) Drainage systems should be properly designed by mosquito control engineers to obtain maximum effect with minimum work at minimum cost.

b) Grades must be used to best advantages and must be even to avoid formation of pockets or potholes.

c) Cross-sections should be as narrow as possible consistent with necessary capacity, and sides should be properly sloped.

d) Laterals should join main ditches at same level, at same grade, and at an acute angle.

e) Culverts and pipes should be carefully laid to exact grade, and protected to avoid formation of potholes at ends.

f) Excavated dirt should be spread or the spoil bank cut through to avoid obstructing water trying to enter the ditch.

g) Cleaning, clearing and grubbing should be carried to a width necessary to permit proper construction of ditch and NO WIDER.

h) Concrete ditch lining is valuable in (1) preventing erosion in both sides and bottoms, (2) providing permanently and properly graded bottoms, and (3) greatly lowering maintenance costs. Design of such work should be by a mosquito control engineer.

i) Sufficient maintenance should be carried on so that at all times the work fulfils the purpose. This is essentially the province of the sanitarian.

j) It is the small details which may mean success or failure. Meticulous attention to details is essential.

Filling.

a) Low areas may be entirely filled, or

b) Filled to a level permitting drainage.

c) Care as to methods and materials used is necessary. Ashes and cinders mixed with earth is preferable. Large fills may be made of earth and rock, but waste such as garbage, rubbish, sawdust may be utilized.

Control of vegetation. Water vegetation and shoreline vegetation are known to serve as harbors for mosquito breeding. It was clearly shown that the cutting of water chestnuts in the Potomac River reduced the Anopheles quadrimaculatus to the point that the necessity for airplane dusting was eliminated. In order to be effective the cutting must be begun sufficiently early in the year to prevent re-seeding for growth the following year.

Another method of plant destruction which is effective also increases the pollution of streams. This method is by chemical destruction. Compounds of the type of 2, 4-D (dichlorophenoxyacetic acid) which are plant hormone phytocides have been used for effective destruction of water plants and marginal growth by the simple method of spraying. Such practices may reduce some malaria field operation budgets by as much as 40%.

The Rational of Insecticiding.

Timing of Control Measures. Larviciding and imagociding (killing adults) must be timed correctly because malaria is essentially a seasonal disease; mosquito breeding is cyclic with the season; some mosquitoes are more prevalent during one season, others at another season; the life cycle of the malaria germ is also rhythmic depending mostly on the season and temperature.

Thus, it is necessary to know the seasonal, diurnal, and climatic habits of mosquitoes, and the seasonal and climatic habits of the malaria parasite in order to be able to institute rational measures of control. Mosquitoes may hibernate over the winter season and possibly cause malaria infection the following spring. In some places, as in Amsterdam, the germs carried by the Anopheles degenerate during the winter and therefore the mosquitoes must be re-infected the following spring by biting malaria carriers before they are again capable of transmitting the disease. In the first instance where infected mosquitoes hibernate over the winter, emphasis should be put on spraying all the habitations, outhouses, stables, and such places in the area where mosquitoes hide in order to destroy as many infected mosquitoes as possible before spring. In the latter case where the germs in the mosquito degenerate during the winter, emphasis should be put on the elimination of human carriers from the area by medical means. These two examples of how various factors indicate the type of emphasis on malaria control is not to be taken as absolute because in those places where finances and facilities are adequate all methods of control measures are instituted, but where such facilities are limited it is important to know where to place emphasis on control.

Some factors which may influence control measures are:

1. In the Temperate zone, malaria is relatively absent.

2. In the tropics, malaria is perenial, but most prevalent at the beginning and end of the rainy season.

3. In the subtropics the greatest prevalence of malaria is usually during the rainy season.

4. In control of malaria, it must be understood that the flight of the anopheles is rarely over 1 mile.

5. In mosquito control it must be understood that some salt marsh mosquitoes have flight ranges of many miles.

6. Some mosquitoes develop only one brood at a particular time, and other mosquitoes may develop several broods during a season.

7. Mosquitoes are attracted by places used for animal habitation.

8. Anopheles bite chiefly at twilight and night. After feeding, they like to roost in dark places in the room or in outbuildings, latrines, storehouses, stables, cowsheds, empty boxes, barrels and the like. When dawn comes they seek the exits of the house and may be found on screen doors and windows.

9. Mosquitoes do not usually like wind.

10. Anopheles larvae are surface feeders, others are subsurface feeders.

11. Most anopheles like fresh water, some are not particular.

12. Malaria is primarily a rural disease.

13. The optimum temperature for development of benign tertian malaria is 77 degrees F., for quartan malaria 72 degrees F. for malignant malaria 86 degrees F.

14. The malaria germ will not develop in the stomach of the mosquito if the temperature be less than 60 degrees F.

15. At the optimum temperature, the malaria germs in the mosquito will develop completely as follows:

a. Benign tertian germ (Plasmodia vivax) in about 11 days.

b. Quartan malaria germ (Plasmodia malariae) in 18 to 21 days.

c. Malignant malaria germ (Plasmodia falciparum) in 10 to 11 days.

16. The water stage of most mosquitoes in more or less optimum conditions is about 8 to 10 days.

17. Malaria is usually rare above several thousand feet altitude.

18. The disturbance of the soil by man usually increases the prevalence of malaria by creating conditions for the anopheles to develop.

19. Malaria is most prevalent where natural drainage is poorest.

20. Mosquitoes are sensitive to changes wrought in their environment.

In carrying on a program of larviciding or adult destruction, it is very important that the plan be organized on a long time basis, and that the measures adopted be executed with clock like regularity. A larviciding program requires that the same place be treated at regular intervals depending on the length of time it requires for certain types of mosquitoes to develop into larvae from the time of deposition of eggs on the water except where the larvicide leaves a long period residual toxicity. Since the duration of this period is variable with the season and types of mosquito, the sanitarian must know enough about the life habits of the particular mosquito to make sound judgment. Where residual toxicity larvicides are not used, weekly treatment of ponds, pools, etc. with larvicide usually suffices in temperate and subtropical areas. In tropical areas where the development of larvae may be quicker, the treatment of waters may be necessary at shorter intervals. The temporary waters formed should be treated not less than 24 hours nor more than 72 hours after the rain.

Adult mosquito destruction by spraying can indeed be effective if carried on with regularity and efficiency. The interval at which habitations in a community should be sprayed depends especially upon the residual toxicity of the insecticides, and the residual build-up from repeated spraying. Pyrethrium spray has a very short residual toxicity, and a fair residual build-up from repeated spraying. Therefore, habitation spraying with pyrethrium should be daily at the beginning to allow the residual build-up, and later the spraying may taper off to one or two week intervals. With the use of synergists the duration of the residual toxicity is lengthened. DDT spray has a very good residual toxicity and residual build-up. The residual toxicity resulting from a single spraying of walls and ceilings at the rate of 200 mg. of DDT per square foot gives effective mosquito killing for at least a season, the duration of effectiveness being less with lesser dosage.

Ordinarily, larviciding against anopheles would be effective if carried on within a radius of 1 mile around the area to be protected. This would also be effective for a good deal of Aedes and Culices, but not for all, especially not the salt marsh mosquitoes. Larviciding against Psorophora

is effective if done for a 200 yard radius around a community.

The secret of any successful mosquito destruction program depends on:

1. The effectiveness of the insecticide and the efficiency of the equipment.
2. The meticulous attention to all details, large and minute.
3. The mental and physical fitness of the personnel.
4. The ability to stick to routine except under emergency conditions, and then the ability to vary the procedure in accordance with the knowledge of the habits of the species to be controlled.

The spread of malaria depends upon 3 fundamental factors:

1. The presence of malaria carriers.
2. The presence of a sustained temperature of 60 degrees F. or above long enough to allow the malaria parasite to develop to completion in the mosquito.

Just as in most communicable diseases, the presence of the malaria carrier is among the most important conditions for sustaining this disease in the community. The human carrier of malaria may remain a carrier for an indefinite period of time. The way to control carriers is by treatment. Thus the attack on the malaria problem belongs both to the sanitarian and the physician.

Larviciding

DDT and the Newer Larvicides. The following outline is a short digest regarding DDT in relation to its larvicidal usage:

1) It is the most effective larvicide and the one of choice for mosquito control where resistant forms have not developed.

2) DDT applied as a spray is equally effective against anopheline and culicine larvae, and is effective against all larval instars.

3) DDT may be applied effectively as a surface application, as an emulsion, or as a suspension. If applied in dosages that are not toxic to fish, reinfestation of the water usually occurs within a week indicating no residual toxicity. If applied in dosages which are toxic to fish, reinfestation of the water is delayed, indicating residual toxicity.

4) If DDT be used as a mosquito larvicide where fish and related organisms are important, the dosage should not exceed approximately 0. 1 pound DDT in 1 gallon fuel oil solution per acre for a single application, or 0. 05 pound DDT in 1 gallon fuel oil solution per acre where repeated application is necessary. A dosage of 0. 1 to 0. 2 pound DDT per acre as a dust will not endanger aquatic life.

5) The distribution of the DDT in the water is limited to the distribution of its solvent. Complete coverage of the breeding area is indicated. Pouring of the material onto one part of a pond, particularly where vegetation is present, will not effectively larvicide the entire surface. See subsequent Item 14.

6) Of the formulae tested, those producing surface films, such as those containing fuel oil and gas-condensate liquor give the most satisfactory control.

7) No pupal mortality has been noted with DDT except when the concentration of solvent was great enough to kill the pupal stage without DDT present.

8) The effect of DDT larvicide on surface organisms is less with dust than with oil or emulsion. Since larviciding is a localized practice it appears that the affect of DDT on the organisms composing fish food is not serious. But, as has been pointed out, DDT may destroy the natural balance between the mosquito larvae and its predators. The resulting imbalance may increase the larva population if the larviciding be not made a continuous process. Therefore the timing element in retreating an area is important.

9) There have been indications from several scattered areas in the world that some species of Anopheles are developing resistance to DDT. However, it does not appear that A. quadrimaculatus in the T. V. A. area has developed a degree of resistance which would significantly affect

control operations with DDT.

10) When a species of mosquito becomes resistant to DDT, as salt marsh mosquitoes have become in several areas, lindane at the rate of 0.1 pound per acre or BHC at the rate of 0.4 pound per acre have been found to be effective larvicides.

11) Comparison of DDT to Paris green.

a. 10% Paris green dust gives approximately the same results as 1% DDT dust for anopheles mosquitoes.

b. DDT-oil-water emulsion or DDT-oil mist gives a higher degree of control for all instars than either DDT dust or Paris green dust.

c. One gallon per acre of DDT-oil formula (.1 pound DDT in 1 gallon No. 2 fuel oil) gives a 36% saving in time as compared with DDT dust for areas about 10 feet wide and over 50% saving in time for wider areas, whereas the above formule is 60% cheaper in cost than Paris green in lime at 1 pound per acre. The latter is also the case for airplane application of the two larvicides.

d) DDT-oil mist requires less time to treat a unit area than DDT-oil emulsion, DDT-dust, or Paris green dust; Paris green and DDT dust requires same time.

12) The most efficient size of DDT aerosol particles in airplane application for the best spread and for best penetration of heavy vegetation is 50 microns or less. The DDT solvent should have a high solvent power in order to give high concentrations, have a low volatility, and be non-corrosive and non-poisonous. The methylated naphthalene Velsicol NR-70 and Sovacide 544B have these qualities.

13) It was found that by melting paradichlorobenzene and adding solvents containing DDT and emulsifiers and DDT in crystalline form, when allowed to congeal around wires (as suspended pellets) and placed in streams was a good larvicide. These pellets disintegrated 50% in 3 1/2 months. Although the amount of DDT dispensed into the water by this technique was very small, a notable decrease in Anopheles occurred. Such a method has possibilities.

14) If DDT in oil be emptied in the water on a rice field, it was found to spread about 125 feet in all directions adequately enough for effective larviciding. Larviciding rice fields may be a very expensive technique if it be done to protect a few scattered homes. It was found that larviciding increases the yield of rice fields.

15) Polluted water seems to decrease the effectiveness of DDT.

16) The following formulae will make up the recommended dosage per acre of 0.05 pound DDT per gallon of fuel oil that will not be toxic to fish:

a. 5% DDT, plus 0.5% B1956 (a proprietary emulsifier-spreader) in No. 2 fuel oil, plus water to make 0.625% emulsion (apply 1 gallon per acre).

b. 5% DDT in sulphonated pine oil, plus water to make 0.625% emulsion (apply 1 gallon per acre.)

c. 1.25% DDT, plus 0.5% Arctic Syntex A in Kerosene (apply 1/2 gallon per acre).

d. 0.625% DDT in diesel oil (apply 1 gallon per acre.)

e. 1.25% DDT in diesel oil (apply 1/2 gallon per acre.)

f. 2.5% DDT, plus 0.5% triton X-100 (a proprietary emulsifier) in xylene, plus water to make 0.625% emulsion (apply 1 gallon per acre.)

17) For residual larviciding in shallow, landlocked, fresh water ponds where fish and other forms of aquatic life are of no significance a DDT emulsion applied as an oil mist spray at the rate of 3 pounds DDT per acre (in 2 gallons of finished spray) will destroy the larvae and the aquatic life. This gives effective control for 3 to 6 months against a variety of Anopheline and Culicine mosquitoes.

18) The recommended treatment when applied by airplane is 0.05 pound to 0.10 pound per acre when applied as a 20% solution in methylated naphthalenes such as Velsical NR70 or Sovacide 544B. Very fine dust containing 2% DDT is also effective for temporary control of Anopheles

larvae, at a dosage rate of 20 pounds per acre. One dose of 10% dust at the rate of 10 pounds per acre will be effective in thick vegetation for 3 weeks. These surface dusts are not effective for the underwater feeders, Culex and Aedes.

19) Resistance develops more rapidly when DDT is used both as larvicide and adulticide, therefore larviciding with DDT and other chlorinated hydrocarbons should be employed only where this method offers the only practical means of control.

For control of DDT-resistant mosquitoes, consideration should be given to the use of the organo-phosphorus compounds of low mammalian toxicity, such as malathion and diazinon, instead of the chlorinated hydrocarbons.

In the presence of DDT-resistant strains, lindane may be used at a rate of 0.1 pound per acre or BHC at 0.4 pound per acre, both applied as fuel oil solutions from airplanes. Residual larviciding with technical BHC (12% gamma isomer) emulsions applied at the rate of 1 pound per acre, (or 2 gals. of finished spray per acre, applied in same manner as oil solutions) has been found satisfactory for land-locked, fresh water ponds against anophelines and Culicines species for 5 to 8 weeks. This is recommended where fish are present since it will do no damage to them.

In small, land-locked, fresh water ponds or in rice fields dieldrin may be used effectively as an emulsion concentrate or wettable powder suspension at the rate of 1 pound per acre. This will prevent mosquitoes breeding for about a year, but will also destroy all aquatic life. This should be used only in emergency.

Preflood application of dieldrin emulsion in the above dosage has controlled rice-field mosquitoes (Psorophora) throughout the season, but was not effective against Anopheles larvae beyond the second week after flooding.

Other recommended larvicides against DDT resistant strains are: Toxaphene at the rate of 0.25 to 0.5 pound per acre, heptachlor at about 0.1 pound per acre, and EPN at 0.035 pound per acre.

Where a mosquito vector of disease has developed a high degree of resistance against space spraying with DDT, toxaphene, lindane, aldrin and heptachlor, it appears that the organophosphate insecticides used as larvicides are very good —malathion at the rate of 0.4 pound per acre, NPD at the rate of 0.4 pound per acre, EPN at the rate of 0.035 pound per acre, and parathion at the rate of 0.01 pound per acre.

For control of Aedes aegypti, vases and other small water containers may be treated with a saturated solution of DDT in 95% ethyl alcohol dispensed with an eye dropper at the rate of one drop to a quart of water. Barrels treated with 35% xylene emulsion concentrate at the rate of about 1 ml. to a 50-gal. barrel may be kept free of larvae for 4 months.

Paris Green. This is a double salt of copper acetate and copper meta-arsenite, $Cu(C_2H_3O_2)_2 \cdot 3\,Cu(ASO_2)_2$ and was introduced as an anopheles larvicide in 1921 by Barber. The new insecticide poisons have minimized Paris green for public health usage in mosquito larviciding. But knowledge of its use should not be quickly lost due to the possibility of too great development of resistant mosquitoes to the new poisons. Its use for a long time was limited to dusting shallow, inaccessible waters or large bodies of water where liquid larvicides were impractical. It lent itself to airplane dusting more effectively than any other larvicide. The effectiveness of Paris green depends on the amount of arsenious oxide (AsO_2) contained in it. Paris green does not harm man, domestic animals, or fish in the dosage used. It is considered effective when the dust contains not less than 50% of this compound and the size of the dust particles vary between 20 and 50 microns. Only a fraction of Paris green is soluble water. It is held on the surface of water by surface tension, since it is heavier than water. The longer it floats the better its killing power against anophelines. Ground dusting with Parish green, introduced in 1929, was accomplished by hand dusters or power dusters mounted on boats, trucks or on foot. The diluting dusts usually used with Paris green are hydrated lime, pulverized road dust, powdered limestone, soapstone, ashes, and stearates of calcium or aluminum. Of these, hydrated lime is the most efficient.

Soapstone is heavier and used for quicker settling. If a long floating period be desired, a diluent that is lighter and less soluble than lime is used, for example stearates of calcium or aluminum. The diluent should pass a 30-mesh screen or finer.

It has been found that Paris green used in dusters is not thrown out from the duster as far as the lime particles due to the greater density of the Paris green and therefore its greater gravitational pull. From all indications the effective larvicidal range from dusters is about 1/2 the distance of the cloud. Where trees and foliage are a barrier to the dust cloud, generous allowance of dust must be used to compensate.

Paris green dusting mixture used in hand dusting application should be composed of about 2 parts by volume Paris green and 98 parts diluent. The dusting mixture to be used in hand operated blowers may range as high as 5% by volume of Paris green. The Paris green portion should be increased where there is wastage due to wind, dampness, or heavy vegetation, or if applied from an airplane. In these cases 5 to 25% of the volume of the dusting mixture should be Paris green.

A mixture box for thoroughly mixing Paris green with dust is made by mounting a box or barrel on its diagonal axis so that it may be revolved. Otherwise a shovel or paddle may be used for mixing.

The mixture is tossed into the air from the windward side to form a cloud. For small bodies of water, where vegetation is heavy, or for ditches and narrow streams, the cloud method is not effective. For the latter, dust is thrown directly on or into vegetation with hands. Hand dust blowers such as used for insect powder or plants are good for such circumstances. For water surfaces which are clean or have only low vegetation, 1/2 ounce of Paris green with 100 parts dust is sufficient for 1,000 square feet of surface. Greater quantities must be used where vegetation is heavy or where mechanical or airplane dusting is used. Paris green and moist sand can be used for Culex and Aedes larvae in shallow water. One man can usually prepare and spread Paris green mixture along about 1 1/4 miles of bank per day.

It will kill second, third and fourth stage Anopheles larvae within a few hours, and needs only to be applied at such intervals as are necessary to prevent larvae, after the first stage, from developing, i.e., at intervals from 4 to 7 days in warm weather. Dusting must be applied without delay when water reveals fourth stage larvae present.

Copper arsenite is superior to Paris green. It must be used in no greater dilution than one part larvicide to 20 parts dust in order to maintain its greatest effectiveness.

Phenol and Cresol. These kill grass and other vegetation, fish and domestic animals, besides killing larvae. They deteriorate on exposure and their effectiveness is reduced by contact with organic materials. As a spray, they are used in the proportion of 1 part larvicide to 15 parts water. Depending upon the pollution of the area to be sprayed, 10 to 20 gallons will suffice per acre. The greater the pollution of the water, the stronger should be the larvicide. A very effective larvicide is: 1 gallon phenol to 50 gallons of oil.

Oiling. This method has been practically replaced by larviciding with chlorinated hydrocarbons. However, it must be remembered that crude oil or waste motor oil when diluted with a kerosene proportion of 20% to 75%, depending upon the viscosity of the oil, is a good larvicide. This should be applied at intervals of one week in the warm weather and about 3 weeks in colder weather, spraying the same place on the same day of the week, and near habitations, about 24 to 72 hours after each rain. In quiet waters containing no vegetation or debris, a gallon of oil will usually produce a satisfactory film over an area of about 100 to 200 square yards. The surface film should remain unbroken for several hours to be effective. If a drip oiler be used, the average flow of 10 to 20 drops per minute will suffice for each foot of width of the water in the stream or ditch.

Drip Oilers. The drip oiler consists of an oil container for the solution or emulsion, such as a 5-gallon oil can or a small drum, which is placed on supports over the stream or ditch so that the liquid will drip through an outlet onto the water below.

The rate of flow from a drip oiler may be regulated in one of several ways. The simplest regulator consists of a nail of suitable size passed through a perforation in the bottom of the can which is slightly larger than the diameter of the nail. The nail is wrapped with cotton, thin cloth, or gauze and the wrapped portion wedged into the perforation. The flow can then be regulated by gently moving the nail up or down until the desired rate be attained. More elaborate regulators, consisting of stop cocks, faucets, pinch cocks, or flexible tubing or wicks, may be employed. However, any type of regulator requires attention to prevent interference with the flow by sediment and by changes in temperature.

Imagociding

The killing of the adult mosquito with swatters, direct spraying, or by impregnation of the habitation with an imagocide, in order to be effective, must be based on certain habits of the Anopheles and certain biological characteristics of its relation to the malarial parasite. These are:

1) After becoming engorged, many species of Anopheles rest at places relatively close to where they obtain their blood meal, such as walls, ceilings, privies and other buildings or dark places close by. They depart from these resting places either soon after daylight or after dusk.

2) About 2 weeks must elapse after the mosquito bites a malaria infected person before it can transmit the disease.

The above factors are the main ones upon which the rationale of imagociding is based. They indicate that the engorged mosquitoes must be destroyed and can be destroyed before they leave the habitations and spread malaria to other places. Because they rest for a long period after feeding, they can be destroyed by impregnating walls, ceilings, etc. with DDT; because they are most active at dusk and dawn this would be the best time to spray habitations with such insecticides as pyrethrum; because they collect on window and door screens at the periods when they try to depart, they can easily be killed by swatting and if the house be not screened they can be swatted before dawn on the walls, ceilings, behind mirrors, under beds, etc., with the use of a dull artificial light.

DDT Spraying. Where resistance is not a problem, DDT is the insecticide of choice for mosquito control. Emulsion sprays of DDT give satisfactory residual toxicity when applied to surfaces such as unpainted wood, plaster, well-dried paints and varnishes, wall paper, unrusted wire screen, and fabrics such as mohair, cotton wool, and canvas. 5% DDT emulsion spray, if applied carefully to prevent runs, will not streak or spot the surfaces. It will dull high-gloss surfaces. DDT crystals may show on glass, shiny metal, and dark enamels.

DDT is not a repellant. It kills, evidently by being absorbed through the insects feet. It does not kill quickly, but does kill effectively. Therefore the mosquito may not die in the home, but it will nevertheless die when it comes into contact with the poison. The duration of lethal exposure is from a quarter of an hour to several hours. Because the Anopheles quadrimaculatus has the characteristic habit of resting on walls and ceilings in houses, privies and other buildings before and after feeding and during the day, and because about two weeks must elapse after the mosquito bites a malaria infected person before it can transmit the disease, house spraying with DDT can be used as an effective measure for controlling malaria.

The following formulae (see also the formulae in Chapter on Insect Control) for DDT concentrate have been found effective, satisfactory, and cheap:

	Summer Formula	Winter Formula
DDT	3 pounds	1 pound
Xylene	3 quarts	2 quarts
Triton X-100	6 fluid ounces	3. 2 fluid ounces
or		
Triton X-155	3 fluid ounces	1. 6 fluid ounces

Larger quantities are made up by proportionately increasing each ingredient.

The reason for the difference between the winter and summer formulae is that xylene dissolves more DDT at warm temperature, than in cooler temperatures below 50° F.

Procedure for making the DDT concentrate:

1) Pour xylene and DDT into a mixing container.
2) Agitate container for 10 to 15 minutes or until DDT has dissolved.
3) Put a sample in a glass; if cloudy continue to agitate.
4) When sample is clear, add Triton (an emulsifier) and continue mixing for a few minutes.
5) Label the container.

This concentrate when mixed with water produces an emulsion. When ready for use, prepare one part of summer concentrate for every 6 parts of water, or one part of winter concentrate for every 3 parts of water. The result is 5% DDT spray. The emulsion is a milky liquid. When sprayed on a surface, the water and xylene evaporate, leaving the desired residue of DDT crystals.

Malathion used as an aerosol of 5% in diesel oil at the rate of twelve gallons per linear mile has been found more effective against adult A. nigromaculis than BHC, DDT, and pyrethrum formulations. It gives good results at distances of 200 yards from the spraying machine. Where possible this toxicant should be used in preference to the chlorinated hydrocarbons against resistant forms of mosquitoes.

Precautions in handling materials:

1) Mix DDT concentrate outdoors whenever possible. Use ventilating fan if indoor mixing be necessary.
2) Wear xylene-resistant, moisture-proof gloves while handling DDT, xylene, or concentrate.
3) Avoid spilling concentrate on clothing or skin. Change clothes immediately if they become soaked, and wash the skin.
4) While spraying:
   a) Wear goggles to protect eyes and respirator to protect lungs.
   b) Wear proper clothing, a wide-brimmed hat, and xylene-resistant, moisture-proof gloves.
   c) Use a greaseless skin lotion to prevent chapping resulting from exposure to xylene.
   d) Wipe face frequently with clean cloth and avoid rubbing spray into eyes.
   e) Wash hands frequently in soapy water.
   f) Take a soapy bath and change clothes after each days' work.
   g) Do not spray baby beds, children's toys, high chairs, food, dishes, silverware, or rooms occupied by sick persons.
   h) Report irritations of skin, severe headaches, dizziness or other conditions to physicians.
   i) If DDT be swallowed, drink mustard water immediately (one tablespoonful dry mustard to one glass warm water), and then consult physician.

Outdoor space spraying is best accomplished with 5% DDT emulsion or oil solution. Against some pest mosquitoes not resistant to DDT, barrier-strip residual spraying with DDT around the outside of individual permises is effective. DDT emulsion at the rate of 5 pounds per acre to the outside of house and to shrubbery, grass and other vegetation for a distance of about 120 feet around houses gives good results against salt-marsh mosquitoes for about 5 weeks. Barrier-strip spraying around cities and towns is not effective against invasion of rice-field mosquitoes (Psorophora confinnis and P. discolor), and salt marsh-mosquitoes.

For DDT resistant adult mosquitoes, lindane is effective as an aerial spray at the rate of 0.05 pound per acre. Dilan as 2.5% emulsion or oil solution may be used as space spray. It is recommended that DDT be used in combination with DDT synergist, such as DMC, against insects which have become resistant against chlorinated hydrocarbons.

Sprayers. These are hand or power operated. The knapsack sprayer consists of a larvicide container, hand pump, and spray nozzle, and is carried and operated by one man. The ordinary sprayer has a capacity of about 5 gallons and a spraying range of about 25 feet. The knapsack sprayer is a practical and economical apparatus for applying oil to ditches, small ponds, or other collections of water which can be reached by the spray.

Larger sprayers may be employed for extensive areas such as the borders of large lakes or in

some instances large swampy places. Such a sprayer usually consists of a barrel or tank container and a pump mounted on a vehicle or in a boat.

A power operated sprayer is used where much spraying is practiced in urban or suburban areas. The most important part of a sprayer is the nozzle. The nozzle aperture should be designed to discharge the emulsion in a flat, fan shaped spray which covers the walls evenly. The spray should consist entirely of very fine particles, like a cloud, with no large drops present. The nozzle must be kept clean and free of clogging particles. It should never be allowed to rest on the ground or any other dirty surface. The operator should be well acquainted with all the equipment. He should know how to dismantle and put it together, how to oil and clean it, how to repair and store it. Before going to a job, the operator must be sure that all his equipment is in good repair and that he carries along with him all such accessory parts and tools as will facilitate his operation, and have an adequate crew of one or two men and a vehicle for transportation. The gaskets, air check valves, and hose are the weak points of the sprayer. Replacements for these parts should always be kept on hand. The operator should, of course, know the details of the technique of spraying, and he should test the sprayer before beginning his work. Power sprayers should be primed with xylene when used for the first time.

Preparation of houses to be sprayed. The following items should be observed:

1) Occupants should be notified well in advance when work will begin.
2) See that all fires are extinguished.
3) All furnishings should be moved away from the walls to the center of rooms and should be placed in such position as will facilitate getting to those whose bottoms or backs are to be sprayed. Be sure that varnished furniture is completely protected by a cover, and that pictures, mirrors and window hangings have been removed from the walls.
4) Examine closets for clothes which might be left hanging on the walls.
5) Be sure that dishes, pots, pans, eating utensils, and food are covered or have been removed from the house.
6) If floors be varnished, see that they are protected with newspapers.
7) Lower window shades to prevent spotting glass with spray.
8) Test the spray nozzle outside the house before starting work inside.

Pyrethrum. The pyrethrins are extracted from the pyrethrum flower by kerosene or other solvents. These pyrethrins kill all species of mosquitoes and certain other insects by destructive action on the central nervous system. The sprays are non-toxic to man and animals (although liberal application of kerosene-pyrethrum spray to the skin may cause local irritation and inflammation). Pyrethrum rapidly disintegrates by a photochemical catalytic reaction when exposed to sunlight and oxygen and therefore has little residual action. Pyrethrum concentrates and sprays should be kept in tightly stoppered, light-proof containers. These should never be left open or in the sun. In sealed containers pyrethrum extracts will maintain their potency for a year or more even in warm climates. If a pyrethrum spray fails within 3 minutes to kill all the adult mosquitoes with which it comes into contact, it no longer contains the standard amount of pyrethrins and is not suitable for use.

Four of the most active ingredients of pyrethrum have now been isolated and are known as Pyrethrins I and II and Cinerins I and II. The separate ingredients are never used in a pure state, but the strength of a pyrethrum solution is usually expressed in terms of the concentration of pyrethrins and the concentration of other active extractives. It is relatively expensive and not practical for large operational programs. Its low toxicity makes it useful for space spraying or aerosols directed at a variety of livestock and household pests. Allethrin is a synthetic material closely related to cinerin but not as effective. Used with synergists, its effectiveness greatly increases. Recently some synergists have been produced for activating the effectiveness of pyrethrins. Besides sesame oil and simple lubricating oil, the first known pyrethrum synergists, there have been produced piperonyl butoxide, piperonyl cyclonene, N-isome, and Synergist 264.

It has been shown that effective temporary malaria control can be carried on by regular and persistent spraying of houses, huts and barracks. Spraying on abode in the evening before retiring and again early in the morning would first of all reduce the number of mosquitoes present that might have fed during the night, and secondly destroy those which might have fed on a malaria carrier or case during the night and became infected. Experience indicates that spraying

unscreened huts regularly at intervals of from several days to two weeks will reduce the malaria incidence appreciably in an endemic area. Although not a repellant, it will, to some degree, deter mosquitoes from entering sprayed dwellings. Pyrethrum may maintain its effect for long periods in sprayed huts by becoming impregnated in the walls and ceilings.

Many formulae have been devised for use of pyrethrum as a spray. Some of the more widely accepted are as follows:

1) Giemsa's Spray -

Pyrethrum tincture (20 parts powdered pyrethrum blossoms to 100 parts alcohol.)	480 grams
Odorless potash soap	180 grams
Glycerine	240 grams

The above is used as spray by diluting it with 20 times its own weight of water.

2) 1 part pyrethrum extract (made by extracting 20 pounds of standardized pyrethrum flowers in one gallon of extract) to 20 parts by volume of kerosene. The extract contains 2 to 2 1/2 grams pyrethrins per 100 c.c. or 75 to 100 grams pyrethrins per gallon. One-half ounce of spray is effective for 1,000 cubic feet.

3) Extract one pound of crude pyrethrum powder in one quart of ethyl alcohol for 24 hours. Dilute the resultant liquid extract with 4 parts by volume of water. One ounce of the oil of penny-royal or citronella should be added to each gallon of the diluted extract.

4) Extract one pound of crude pyrethrum powder with one quart of chloroform for several hours. Filter the extract. Add sufficient kerosene to the filtrate to make 1 gallon.

Pyrethrum powder has been used as a fumigant against mosquitoes. The powder is set on fire with a little alcohol. Two pounds of the powder is used per 1,000 cubic feet of space. The exposure period should be about four hours. This does not certainly kill the insects but stupifies them. They should then be swept up and burned.

A very effective spray has been devised by the Army for use in the tropics. It is made in the form of a bomb, having a valve which is easily opened or closed. The spray is called FREON - pyrethrum aerosol —and is composed of:

Pyrethrum	1%
Sesame oil	2%
Liquid Freon (dichloro-difluoro-methane	97%

The sesame oil acts as a synergist, or activator, in augmenting the lethal effect of the pyrethrum. The liquid freon volatilizes and produces the pressure within the bomb. The spray continues till the last drop of liquid evaporates. As the freon containing the insecticide is sprayed, it forms a fine mist from which the solvent evaporates almost immediately, leaving the pyrethrum and sesame suspended in the air as a cloud of fine droplets called an aerosol. The freon is non-toxic to man and mosquito and it is non-inflammable. It is used simply as an expellent to disperse the pyrethrum and oil of sesame.

The pressure in freon cylinders varies with the temperature: It is 37 pounds per square inch at 40° F., 84 pounds at 80° F., and 116 pounds at 100° F., 205 pounds at 140° F. The one pound bomb is sufficient to spray between 100,000 and 150,000 cubic feet of space when properly used. The spray can issue forth 12 to 14 minutes of continuous use. To spray a room, the bomb is carried rapidly toward all corners of the room while the spray is allowed to escape. No direct hit on mosquitoes should be attempted, since this wastes spray. About four seconds of spraying per 1000 cubic feet is usually sufficient. It is best to spray under the eaves of a dwelling before going inside. The freon-pyrethrum spray is so effective that it can be used sparingly and without wastage.

DDT may be included in aerosol formulae, and vegetable or mineral oils may be effectively substituted for sesame oil. Two such formulae used at the rate of 3 to 5 gm. per 1000 cubic feet of space are:

Pyrethrum (20% pyrethrins) 5%
DDT 3%
Cyclohexanone (auxiliary solvent) . . 5%
Lubricating oil S. A. F. 30 . . . . . 2%
Freon 12 . . . . . 85%

Pyrethrum (20% pyrethrins) 6%
DDT 2%
Alkylated naphthalene (PD 544 or
Velsicol AR-60 . . . . . 8%
Freon 12 . . . . . 84%

Pyrethrum insecticides can be effectively sprayed with a good hand atomizer or with a paint gun sprayer at an air pressure of fifteen pounds. The source of pressure may be in tanks pumped up by hand or by gasoline or electric motor-driven compressors. Solidified carbon dioxide (dry ice) when available, in suitably constructed pressure tanks, is a good expellent.

Screening.

Suitable wire of proper mesh should be used. Many types of wire screening are made. Steel wire cloth is most common, either painted or electro-galvanized. The quality of paint and of galvanizing may vary greatly in different lots of wire. Pure copper wire, bronze wire (90% copper, 10% tin), monel wire (nickle-cobalt alloy), stainless steel, and aluminum all have been used. In most areas, a good quality electro-galvanized screen will be satisfactory but in warm climates, especially along the sea, it is better to use wire of a non-corrosive material, such as bronze or aluminim. A hard drawn wire, 99.8% copper, and of heavy grade is suitable. Aluminum wire screening is also good.

The diameters of wire and aperture are important. In general it is not safe to use screening which has apertures larger than 0.0475 inch in diameter. Heavy grade copper wire screening having 16 meshes to the inch, will have a wire diameter of 0.0150 inch and a mesh diameter of 0.0475 inch, but regular 16-mesh wire screening has an aperture of mesh measuring 0.0512 inch, which will not exclude all malaria vectors and will not keep out Aedes species. Standard 18-mesh wire screening has a wire diameter of 0.0090 to 0.0100 inch and a mesh which is 0.0456 inch in diameter.

The screening must be so applied that breakage will be minimal, and that the doors and windows will not facilitate mosquito passage. For instance, screen doors should open outwards, and should be on the windward side of a building, if possible. They should be strongly constructed so that they will not sag or warp. They require springs so that they will close automatically. The places where a foot or hand would naturally be applied to open a screen door should be protected with a cross strip of wood or metal. To block entry of mosquitoes through the space between door frame and door, the door should close tightly against a broad surface, such as a batten at both sides and both ends.

Zinc in certain paints sometimes used on door or window screen frames and the iron in galvanized nails sometimes used to fasten screening to a frame will react with copper screening and cause splitting at the point of contact. In highly malarious areas, it is desirable to have double screen door barriers with a vestibule between them.

Careful attention must be paid to the closing of all possible apertures not screened, such as cracks and knot holes, spaces where floor or wall boards have separated, openings between flooring and walls, corner openings where joists come together, holes where window shutter prop-sticks extend into a room for easy handling, ventilating pipes and shafts, etc. Holes may be covered with tin shingles or pieces cut from ordinary tin cans. A filler for holes and cracks may be made by boiling shredded paper and flour into a fairly homogeneous mass and then adding sand and cement to form a plaster which may be molded into the holes. This filler is somewhat pliable and will retain its place fairly well. Toilet paper is a suitable tissue for use in making this filler.

Proper routine maintenance of screening is essential, with prompt and effective repair of dents and tears, and discovery and blocking of new cracks and knot holes. In malarious areas

the great importance of these apertures for mosquitoes is out of proportion of their seeming insignificance.

Repellents.

The most effective repellent that has been discovered to date is 6-2-2 which is a mixture of 3 effective repellents in the proportion of:

Dimethyl phthalate	6 parts
Rutgers 612	2 parts
Indalone	2 parts

This has been adopted as standard-issue by the U. S. Army. It can be applied to the skin but should not be applied around the lips nor eyes. When applied to the skin over exposed parts of the body, these repellents will protect for 2 or more hours despite even profuse sweating. When clothes have been treated at the rate of 2 grams of repellent per square foot of cloth or approximately 5% of the dry weight of the clothes, it remains effective for ten or more days. These repellents damage objects made of plastics, synthetic clothes and similar products. Other available mosquito repellents are 2-butyl-2-ethyl-1, 3-propanediol and Undecylenic acid. Research in repellents is proceeding apace.

Personal Protection

Besides the use of repellents for preventing mosquitoes from biting individuals, other methods are also employed, especially in camps and outdoor life.

Mosquito nets or bars are useful in protecting individuals from being bitten while asleep. They must be so adjusted and used that mosquitoes cannot feed through the mesh. Therefore the net must not touch the sleeper. Overhead frames should be provided for beds upon which to suspend the net. The lower edge must be so tucked in that no opening be available for mosquitoes to enter. The frames should not have sharp points which will catch and tear the netting. Nets used in small tents should be suspended from and conform to the shape of the interior of the tent. Shelter tent nets should not be used over the outside of the tents but hung inside. Nets should be folded up by day. When the net is entered at night, the interior should be inspected for stray mosquitoes.

The best material for nets is a stiff bobbinet. Such materials as cheese cloth, tobacco cloth and butter cloth, are not suitable because they almost completely prevent proper ventilation. The size of the holes should not exceed 0. 0475 inch in any dimension in order to exclude all species of mosquitoes. To exclude sandflies, the largest permissable diameter is 0. 0334 inch. The top as well as the sides should be of netting to allow for a better circulation of air. Strong reinforcing at the corners is necessary and repairs should be prompt and complete. Adhesive tape, sewing or patching may be used to repair rents in the netting.

Men on guard duty or forced to remain out after dusk in malarious country may wear head nets and gloves as supplementary protective measures. Head nets have certain disadvantages. They impair vision and add to discomfort in warm climates. Vision is least impaired by black nets and usually this color attracts mosquitoes least. Shirt sleeves should be kept down after sunset. Slacks, not shorts should be worn. By keeping the trouser legs encased in leggings, or tucked into high boots, mosquitoes are kept from biting the ankles. Mosquito boots of canvas, suede, or goatskin may be useful if long enough to protect the legs nearly to the knee. The efficiency of protective clothing varies directly with the amount of care and discipline that the individuals take in using them.

Naturalistic Control.

Mosquito breeding seems to be limited more by physical conditions such as available water, temperature and humidity than by specific parasites which appreciably restrain the aquatic stages of mosquito development. It is true that there are numerous organisms which are predators of mosquito larvae, many kinds of fish, for example, being effective under certain conditions. But in general, under natural conditions, there is usually established a balance between predators and victims, and in the case of mosquitoes this balance is frequently at a level which permits a fairly large output of mosquitoes with an appreciable nuisance or disease-transmitting capacity. Therefore, in general, the effective control of mosquitoes by true parasites appears to be improbable, and control by predators is successful only under particular conditions and within fairly well defined limits.

But careful study of mosquito biology has shown that many species of mosquitoes are very susceptible to changes in their environment. Slight changes in their environment, and slight changes in the breeding water make it impossible for a particular species to reproduce in significant numbers. Furthermore, in many instances it is possible to bring about slight but effectively unfavorable changes in environment by fairly simple methods which involve relatively small costs. Such simple environmental changes are termed "naturalistic" abatement methods.

Naturalistic abatement measures are not new, though their application has materially increased in the last few years. Stream bed flushing, for example, was used by Sir Ronald Ross at Ismalia, in 1903, and by J. A. Leprince at Panama in 1903. Dr. Henry Rose Carter of the U. S. Public Health Service as far back as 1914 saw the significance of the changes in water level in southern mill ponds due to the week-end shut down diminishing the breeding of Anopheles quadrimaculatus, and this observation has been the basis of one of the principal control methods used today against this mosquito in impounding reservoirs in the southeastern states. Naturalistic abatement measures have been used in Malaya, Ceylon and India. L. W. Hackett and his associates have developed their application in Europe; and in California W. B. Herms has for many years laid emphasis on the ecological phases of the problem, which emphasis is the basis of all naturalistic control.

For convenience, and to assist in the organization of thought on the subject, we will group naturalistic measures into three categories — chemical, physical and biological, as follows:

Chemical: Changing the salt content of water by salinification and freshening, and pollution.

Physical: Silting, muddying, intermittent drying, constant level flooding with circulation, fluctuating water levels, controlled reflooding and redraining, flushing or sluicing, and changes in sunlight by shading and clearing.

Biological: Introduction of natural enemies (parasites and predators), changing flora and fauna to competitive or unsuitable types, and elimination or destruction of aquatic food supplies.

Some Examples of Naturalistic Mosquito Control

At Durazzo, Albania, the most effective malaria vector in the Mediterranean Basin was markedly controlled by salinifying the marshes with sea water, whereas in Italy malaria carrying mosquitoes were decreased by preventing salty water along the coast from salinifying the coastal marshes, thereby keeping the water fresh.

More than 500 acres of salt marsh in Alameda County, California, have been eliminated as mosquito breeders by silting in the past 10 years.

In Solano County, California, extensive areas of marshes have been cleared of Aedes dorsalis breeding by 7 to 10 cycles of flooding and rapid draining.

In the southern states and particularly many localities in the area of the Tennessee Valley Authority, the use of fluctuating water level in impounded water for control of Anopheles quadrimaculatus has been successful.

Successful naturalistic methods of mosquito abatement are not evolved overnight by some lucky guess or feat of imagination. Their development requires patient and often prolonged investigation of a mosquito species in relation to its environment, and they are usually the product of intense study by men trained along biological and especially ecological lines.

Aedes aegypti control

This consists of:

1) The control of breeding in artificial containers in immediate proximity to houses.
2) Adequate premise inspection service.
   a. Must be painstaking and thorough.
   b. All containers must be found and controlled.
   c. Repeated reinspection must be made to keep control of containers.

Use of Catching Stations

The extent of mosquito breeding in an area and the effectiveness of mosquito control measures may be determined by inspections of potential breeding areas for the presence of larvae and by investigations of the prevalence of adult mosquitoes. Both measures are important.

The fact that mosquito breeding is taking place as indicated by the presence of larvae does not necessarily indicate that mosquito production of an appreciable degree is likewise taking place. The density of breeding and the species breeding in a particular area may vary greatly during the breeding season. To get a reasonably complete picture of the extent and kind of mosquito breeding by inspections for larvae at all periods would be very difficult and expensive.

As a preliminary to the planning of a control program, an analysis of the problem should be made. In addition to mapping the location of potential breeding places and planning for their elimination or control, a survey should be made to determine what kinds of mosquitoes are prevalent, and when; which of them are of sufficient importance to warrant the cost of control measures, when control should be started and when it may be stopped.

Only when we have a clear and definite knowledge of such factors is it possible to plan and conduct a control program that will give a maximum degree of control at a minimum cost.

Much pertinent information on these points can be obtained by looking for adult mosquitoes in places where they are likely to be found if present in the area. Such places are called "catching stations."

Checking effectiveness of work by use of catching stations:

1. Select a number of stations, not more than six or eight per square mile near important breeding areas, and if possible between those areas and habitations.
2. Do not neglect "biting" catching stations.
3. Visit each and make a recorded count of species and numbers once each week.
4. Use comparative species and numbers records to determine locations of missed or unknown breeding places.

Types of Catching Stations

The sort of places used as catching stations depends on local conditions. Among the most commonly used are dwellings, particularly in bedrooms and behind pictures or furniture; underneath houses; in culverts and under bridges; in barns and sheds where animals are kept; in hallow logs or trees; in privies; and in spots where the observer stands as bait. These last are called "biting stations."

The most important considerations in the selection of a catching station are: (1) the station should be easily accessible; (2) it should be easy to see and reach all surfaces where mosquitoes may rest; (3) the station should afford the resting mosquito shelter from rain, wind and direct sunlight; (4) it should be such as to attract mosquitoes so that if present in the neighborhood they will be found in such a place; and (5) it should be of such a character that other similar places may be found in the area.

The inside of houses or barracks are often very important as catching stations. Frequently, the finding of large numbers of mosquitoes inside the house may indicate that breeding is taking place inside the house. This is especially true of Aedes aegypti. For surveys, and for some research work, the under side of dwellings offers an important catching area. Anophelines are often found on the under side of fireplaces. For routine work, however, such places may not be sufficiently accessible. Barns and sheds where animals are kept sometimes are good places. In rural and suburban areas, privies have been found to be the best type of catching station for the anophelines and for some of the worst of the pest mosquitoes. They fulfill all the requirements and are particularly good if old, not exposed to direct sunlight, and well provided with cobwebs.

Army camp tents are good catching stations, and the area just over the folded door flaps is a favored resting spot.

Some of the worst pest mosquitoes, notably Psorophora and to some extent Mansonia Perturbans,

do not appear to frequent structures and are best taken at "biting" catching stations. By this we mean taking a position near suspected breeding places, exposing part of the body as bait and catching the mosquito while it bites. The group of swampy woods Aedes are vicious biters and may be easily located in this manner. The stations must be quite close to breeding areas, as these species apparently do not normally fly far in any great numbers but will bite readily if disturbed during the day. Aedes aegypti may also be caught at biting stations during the day. For most types, however, and particularly for Anophelines, the best catches are made at dusk as this is the time they move from breeding areas or daytime resting places to their nightly feeding grounds. Where possible the direction of flight should be noted. The genus Uranotaenia frequents concrete culverts, and the genus Culiseta likes to roost under concrete bridges.

The best type of catching stations for various species of mosquitoes which are of health, pest or economic importance are:

a. Privy catching stations,which are best for Anopheles quadrimaculatus, A. crucians, A. punctipennis, Culex quinquefasciatus, C. salinarius, C. restuans, C. nigripalpus.

b. Biting catching stations,which are best for Aedes aegypti, A. triseriatus, A. vexans, A. atlanticus, A. infirmatus, A. dupreei, A. bimaculatus, Psorophora ciliata, P. cyanescens, P. ferox, Mansonia perturbans.

c. Biting catching stations near salt marsh areas,which are best for Aedes solicitans, and A. taeniorhynchus.

d. Concrete culvert catching stations,which are best for Uranotaenia larvi and U. sapphar-ina.

e. Under concrete bridge catching stations,which are best for Culiseta inornata.

f. Tent catching stations,which are best for Psorophora columbiae.

Catching Stations in Surveys

There is a limitation to the use of catching stations that should be emphasized. The resting places used in cold weather by most of our species are not those mentioned. In fact we do not know much about the winter resting places of our most important species. It is, therefore, not practicable to make a thorough mosquito survey in some sections during the winter. Surveys should be made in warm weather when adults will frequent the kind of places mentioned.

The density of breeding, the rate of production, and the species breeding in an area may change during the year. In order to get a reasonably accurate idea of the mosquito problem, it is necessary to take a census of the mosquito population several times during the year and to include all "samples" in the report of the survey.

The purpose of such a survey is to determine (1) the different species present in the area, (2) the location where each is found, (3) the prevalence of those important as pests and disease carriers, (4) the time when rate of production becomes important, and (5) the time when production stops or when the rate becomes low enough to warrent stopping control measures.

To secure such information a large number of catching stations should be selected. In each section of the area there should be different kinds of catching stations established and so chosen that any mosquito present is likely to be found in some of the stations. Care should be taken to locate catching stations near any suspected breeding areas and "biting stations" should not be neglected.

The question as to whether mosquitoes should be caught or merely counted is a moot one. In general, it will be found that with a little experience many of those found may be identified. To catch and add these to a collection would be a waste of time. Those which can not be thus identified should, by all means, be caught, identified in the field, if possible, and if not, sent to an entomologist for identification. The purpose of the survey is to get information about all mosquitoes present, and this cannot be obtained if any large number be left unaccounted for or unidentified.

A simple system of records should be kept. For the base record, a loose-leaf notebook is suggested, with a sheet for each station. A map of the area should be made showing the location of each catching station with a list of the species found in each. On this or another map may be shown the location of breeding areas, layout and schedule of drainage and oiling operations. A

graph showing relative prevalence of different species at different times of the year will be found worthwhile.

It is not necessary to await the result of a detailed survey before doing control work. An inspection of the area and a reconnaisance survey will locate many actual and potential breeding places. Control may be planned and started with these as a basis and the procedure amended and improved as the work proceeds and as indicated by the census of imagos.

In routine control,work catching stations serve another purpose. The objective here is not to determine the prevalence of all kinds of mosquitoes but rather to check on the effectiveness of control measures by a rapid determination of the prevalence in each section of the area of a few troublesome species. The number, the location and the kind of catching stations should be selected with this in mind.

Where special problems such as control of the swampy woods Aedes, or the domestic Aedes aegypti are being studies, it is necessary to establish a number of catching stations because of the short flight range of these species. In most kinds of work, the control of these short flight species is of minor importance. All of the most important species can be found if a comparatively few good catching stations be established and checked frequently, weekly, if possible, but at least two or three times a month. They should be located adjacent to houses near breeding areas, and then may be supplemented by biting stations nearer the suspected breeding areas of the short flight range species.

Once control work is in progress, the use of catching stations is almost a necessity. In general, control operations are planned and conducted not to prevent completely the breeding of mosquitoes, but to prevent production. In places where drainage only is relied upon, it may be expected that a certain amount of breeding will take place, but unless this progresses to the stage of actual production, it is not important. However, it is very difficult to tell from merely observing the presence of larvae whether the place be actually producing adult mosquitoes. The use of catching stations will tell and will indicate when the condition of the ditch has developed to a point where maintenance is needed and whether supplemental larviciding operations be required to prevent an objectionable rate or production.

In oiling or larviciding programs, larvae may be expected to reach the fourth instar, or even the pupa stage, between oilings. It is frequently impossible to say with confidence, from larval observations alone, whether the next application prevents production, or whether some production may have occurred just previous to that oiling. The presence of adults, as shown by observations at catching stations will tell.

It is often very difficult to locate every single place in which breeding is taking place. No amount of checking on the condition of known breeding places will prevent production in a place the location of which is not known. Frequently the use of catching stations has indicated that such a place must be nearby and a more diligent search which otherwise would not have been made may locate it.

Frequently, breeding places develop or are created during the control period and are discovered through the use of catching stations. Sometimes mosquitoes find favorable conditions and may produce in numbers sufficient to discredit the control program and endanger popular and financial support before production is discovered unless catching stations be properly used.

Mosquito Traps.

Sometimes it is desirable to make a collection of specimens of adults over a period of time. Traps are useful in this respect. A very simple trap can be made with a screened box on the principle of the old time rat trap, one side of which is made up of a cone of wire with a small opening into the center of the box. This screened box can be placed in any mosquito catching station with the cone on the bottom of the box. It can be hung in privies, under bridges and culverts and in similar places. The mosquitoes caught can be collected in the ordinary chloroform tube and preserved for study and classification.

Some investigators have used a more elaborate system incorporating a light to attract the

mosquitoes and a fan to blow them into the cone of wire. The cone could empty into a small box or a screw cap bottle. The fan means that electricity must be available. The fan can be hung above the light while the cone is placed below the light. The insects attracted to the light are not broken by the fan but are blown into the cone and from there to the bottle. This method is selective in that only certain species are attracted to light. Changing the color and/or intensity of the light bulb may vary the types of mosquitoes caught. The investigator should not hesitate to experiment with traps, bait, and methods of his own devising.

Collection of Mosquitoes for Identification (See Fig. 3, 4.)

Larvae, or wiggletails are collected for breeding in aluminum bread pans measuring 10 by 15 inches by 3 inches deep, painted white inside with enamel. To remove larvae from dipper to vials or rearing jars, the ordinary medicine dropper with rubber bulb, but with the glass tip cut off to give a larger bore, may be used. Larvae may be prepared for shipment for identification by placing them in small vials containing 70% alcohol or 10% commercial formalin filled to the top with liquid so that no air-bubble is present.

To obtain adult mosquitoes for identification, if wiggletails or pupae have been collected, the pupae should be separated from the larvae and placed in a pint fruit jar about half filled with the water in which they were found, and netting should be placed over the top of the jar. The wiggletails should be kept in cups or shallow pans in the same water in which they were found, and, as they transform into pupae, they may be placed in the jar with other pupae. When a number of mosquitoes have emerged, they should be allowed to "harden" for 24 hours, and then a wad of cotton saturated with chloroform may be placed on the netting over the jar until the mosquitoes have dropped to the surface of the water. The jar is then rapidly emptied into a dish, the remaining pupae are transferred to fresh water, and the adult mosquitoes are picked up with tweezers and placed in a chloroform tube until dead. Tobacco smoke may be used to kill the adults if chloroform be not available.

For capturing adult mosquitoes, a small net on a handle is useful in collecting specimens, but a small glass vial, straight-sided and without a lip, is usually all that is necessary. The vial can be slipped over the mosquito while at rest. The advantage of the glass vial is that less damage is apt to be done to the mosquito than if swept into a net. A cyanide bottle is a useful collecting device. This is made by pouring about one-inch depth of wet plaster of paris over a small quantity of sodium or potassium cyanide in the bottom of the vial, and covering it with circular disk of blotting paper. A similar vial using chloroform-saturated cotton is a substitute for the cyanide bottle. A chloroform tube may also be made by placing a number of rubber bands cut in small pieces, or a rubber stopper of proper diameter in the bottom of a test tube. The rubber is saturated with chloroform and a small piece of cotton placed on top of the rubber. Over the cotton is placed a disk of blotting paper. The tube should be kept tightly corked.

If it be desired to catch the mosquitoes and keep them alive, the sucking tube is the best device. This is made of a piece of three-quarter inch diameter glass tubing about one foot long, drawn abruptly down to a diameter of about one-fourth inch at one end. To this end attach about two feet of quarter-inch rubber tubing. Fit a piece of fine wire gauze into the small end of the glass tube to prevent specimens being sucked into the rubber tube. In operation, the open end of the rubber tube is inserted into the mouth, and the open end of the glass tube is placed near the mosquito; a sharp suck of the breath pulls the mosquito into the tube. The palm of the left hand should be quickly placed over the open end of the glass tube, and the mosquito examined and approximately identified. If it be kept, it can then be blown into a collecting bottle. Adult mosquitoes should always be handled with tweezers and not fingers, since they are so fragile and the spots on their wings easily rub off. In grass, sweeping with a collection net may be the only successful method for collecting specimens.

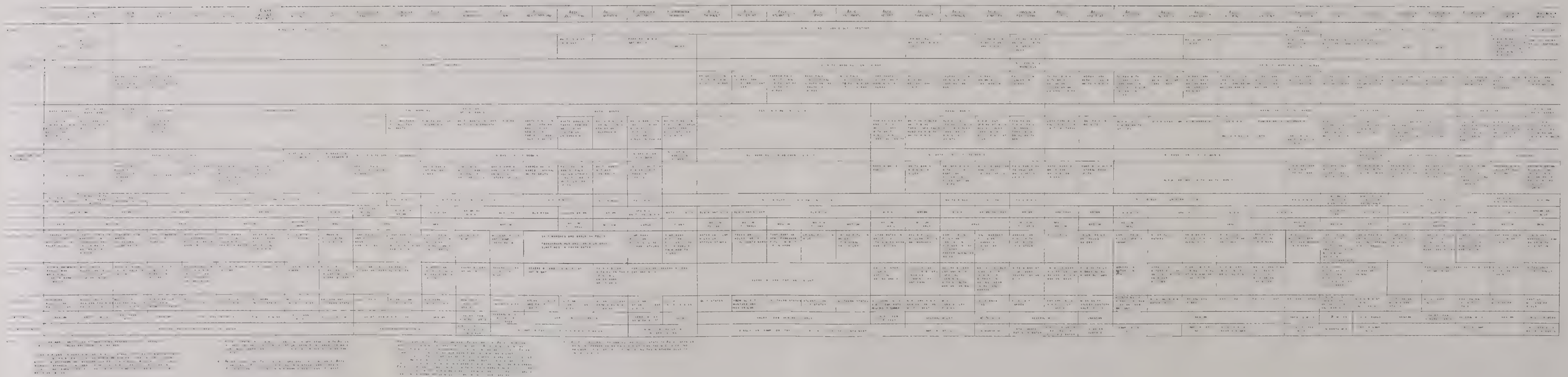
Adult mosquitoes may be prepared for shipment by placing them between loose layers of tissue paper in pill boxes, properly labelled. A wooden cigar box makes an excellent container for mailing.

Dissection of Mosquitoes

The methods of controlling diseases are based on the principles of epidemiology, i. e., if we know how diseases spread, we can devise techniques to prevent such spread. The fundamentals

CHART 15

HOW TO DISTINGUISH THE MORE COMMON CULICINE MOSQUITOES OF THE UNITED STATES



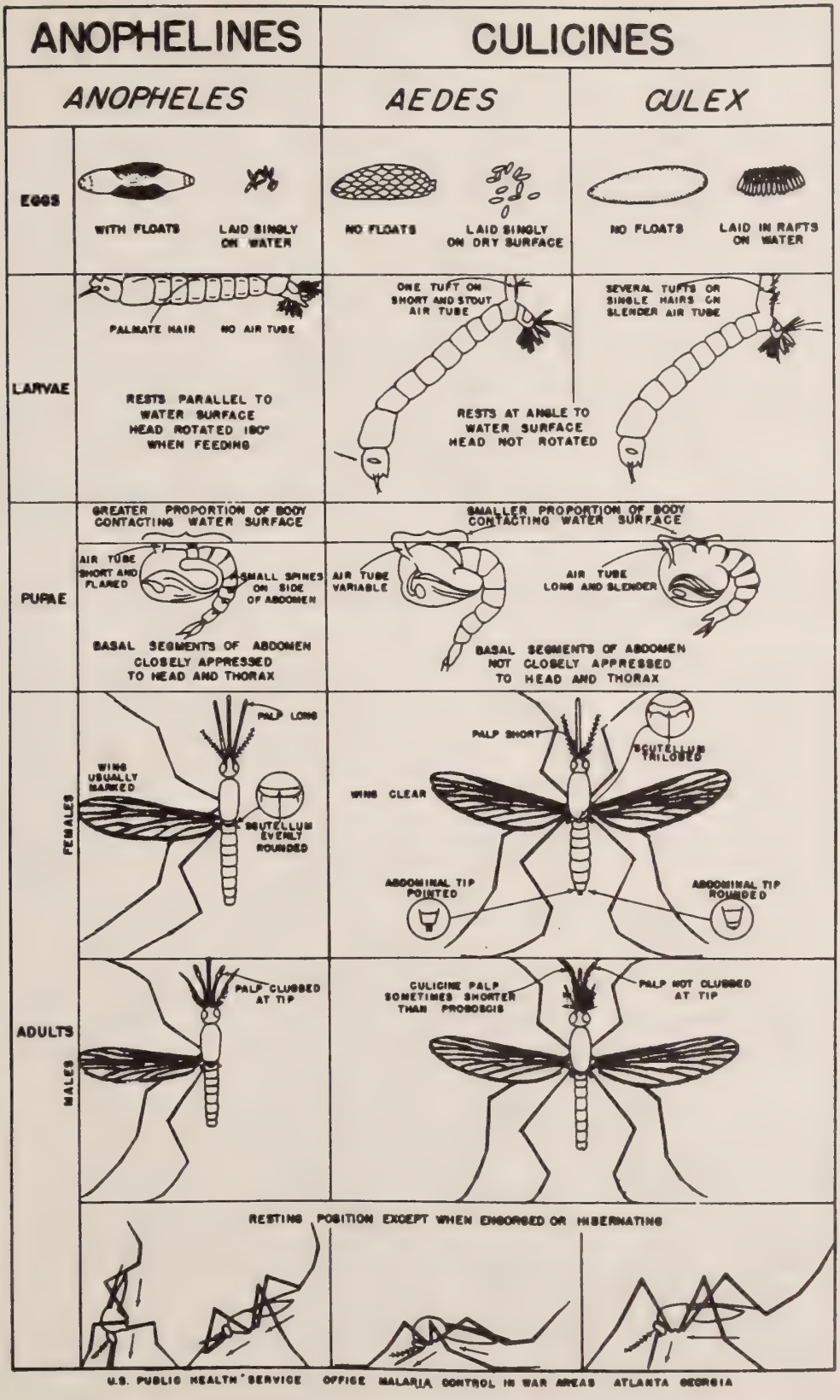

ANOPHELINES
CULICINES
ANOPHELES
AEDES
CULEX
EGGS
WITH FLOATS
LAID SINGLY ON WATER
NO FLOATS
LAID SINGLY ON DRY SURFACE
NO FLOATS
LAID IN RAFTS ON WATER
LARVAE
PALMATE HAIR
NO AIR TUBE
RESTS PARALLEL TO WATER SURFACE HEAD ROTATED 180° WHEN FEEDING
ONE TUFT ON SHORT AND STOUT AIR TUBE
RESTS AT ANGLE TO WATER SURFACE HEAD NOT ROTATED
SEVERAL TUFTS OR SINGLE HAIRS ON SLENDER AIR TUBE
PUPAE
GREATER PROPORTION OF BODY CONTACTING WATER SURFACE
SMALLER PROPORTION OF BODY CONTACTING WATER SURFACE
AIR TUBE SHORT AND FLARED
SMALL SPINES ON SIDE OF ABDOMEN
BASAL SEGMENTS OF ABDOMEN CLOSELY APPRESSED TO HEAD AND THORAX
AIR TUBE VARIABLE
AIR TUBE LONG AND SLENDER
BASAL SEGMENTS OF ABDOMEN NOT CLOSELY APPRESSED TO HEAD AND THORAX
ADULTS
FEMALES
PALP LONG
WING USUALLY MARKED
SCUTELLUM EVENLY ROUNDED
PALP SHORT
SCUTELLUM TRILOBED
WING CLEAR
ABDOMINAL TIP POINTED
ABDOMINAL TIP ROUNDED
MALES
PALP CLUBBED AT TIP
CULICINE PALP SOMETIMES SHORTER THAN PROBOSCIS
PALP NOT CLUBBED AT TIP
RESTING POSITION EXCEPT WHEN ENGORGED OR HIBERNATING
U.S. PUBLIC HEALTH SERVICE OFFICE MALARIA CONTROL IN WAR AREAS ATLANTA GEORGIA

Fig. 3

of malaria epidemiology are well known, but because of the variable factors from area to area, due to differences in climate, geography, human customs, habitations, types of mosquitoes, and such, it becomes necessary for any malaria control unit to survey each particular area in which it expects to develop control work in order that a clear estimate of the situation be at hand. This estimate will bring into focus the important characteristics of the situation resulting from the numerous variable factors at play.

Such information as:

1. The type of anopheles which is mostly or solely responsible for the spread of malaria.
2. The rate of infected anopheles in the area.
3. The always threatening possibility as to whether other mosquitoes than anopheles may become responsible for the spread.
4. The relationship of the rate of infected mosquitoes to infected humans can be obtained only by the dissection of adult female mosquitoes and the examination of these mosquitoes under a microscope for evidence of the infection. The technique of this work can be delegated to well trained sanitarians working under the supervision of biologists.

Two parts of the mosquitoes internal anatomy require examination to determine whether infection be present, namely, the stomach or bulging posterior part of the midgut, and the salivary glands. In the outer lining of the stomach wall the infected mosquitoes may show the small round cysts in which the malaria germs develop (see 4 in Chart 3). In the salivary gland may be found thousands of the small slender wormlike parasites, which migrated there after having burst forth from the stomach cysts (see 5 in Chart 3).

The Dissection of the Midgut

1. Identify the mosquito to be dissected after having killed it by concussion or chloroform in a test tube. Remove the wings and legs with a pair of forceps and scissors. (Some experts do not take the trouble to remove these appendages.)
2. Place the trimmed mosquito in a drop of saline solution, colored light blue with methylene blue, on a slide resting on a light background. (Some workers prefer not to add saline until the gut is drawn out.)
3. Arrange the insect on its side with the abdomen pointing toward you. With the needle held in the left hand, transfix the thorax and turn the mosquito ventral side up with the abdomen still pointing toward you.
4. While so held, bring the needle in the right hand to work and nick the chitin on either side of the abdomen so as to separate the last two segments or so. (See 1 in Chart 3.)
5. Place the needle on the partially separated segments and then carefully, by alternately pulling and relaxing, pull the severed segments and attached viscera away from the rest of the abdomen. (See 2 in Chart 3.)
6. As soon as the severed segments are separated from the rest of the abdomen, place the preparation on the dark background. Observe the whitish viscera stretching between the separated portions and exerting traction steadily draw these gradually out until the midgut, a long centrally placed viscus, slips from the abdomen. If this organ threatens to break, prod the thorax still held by the left hand needle several times with the free needle in the right hand to loosen the anterior attachment of the midgut and again put on the traction.
7. Cover the mass of viscera now lying on the slide with a coverglass and make out the structures as shown in 4 of Chart 3.
   a. The MIDGUT with a swollen posterior portion and a narrow interior portion.
   b. The PYLORUS with the origin of the malpighian tubules and the pyloric ampulla.
   c. The INTESTINE ending in the large RECTUM furnished with rectal papillae.
   d. The MALPIGHIAN tubules opening into the pyloric ampulla and lying more or less parallel to the intestine which they surround.
   e. The OVARIES which may be laden with eggs.
8. When the sanitarian has become proficient in dissection, step 7 may be modified by cutting across the intestine just below the pylorus when the midgut has been withdrawn from the abdomen. Then remove the hindgut with the needle, thus leaving only the midgut for examination. Remove all extraneous matter from the neighborhood of the midgut by washing with saline and wiping with filter paper.
9. Place coverglass on the midgut and examine under microscope (two-thirds objective) for cysts in the outer covering of the midgut (See 4 in Chart 3). Do not confuse large detached

epithelial cells or fat globules for cysts. Cysts are clear round or oval bodies without a refractile wall but with unmistakable pigment granules.

The Dissection of the Salivary Glands

1. Identify the mosquito to be dissected after having killed it by concussion or chloroform in a test tube. Remove the wings and legs with a pair of forceps and scissors.

2. Place the trimmed insect in a small drop of saline solution colored with methylene blue against a light background.

3. Arrange it on its right side with its head toward you. Place the needle held in the left hand across the thorax and exert gentle pressure so as to make the soft parts about the neck bulge. Place the other needle just behind the head and simultaneously pressing with the left and pulling with the right drag the head toward you. Under a dissecting lens it will be seen that the glands by this method drag out attached to the neck. (See 3 in Chart 2.)

4. Without removing either needle or letting go of the head, cut downward with the right hand so as to sever the tag of tissue attached to the neck. This tag should consist mainly of the glands.

5. If these be not seen as refractile bodies in the mass, press again with the needle lying on the thorax and with the other needle scoop out such tissues that present themselves easily at the opening from which the head has been torn. If not actually included in the portion severed from the neck the glands will be found in the piece of tissue last removed.

6. When, under a dissecting lens or the low power, the glands are seen to be present, remove all debris, cover with a coverglass and examine.

7. For the sake of practice, the beginner should identify the 6 salivary glands (3 on each side) which appear as blue stained refractile bodies (under a two-thirds objective) made up of more or less clearly defined cells.

8. The glands are covered with coverglass and the glass gently pressed to crush the tissue. Then the fluid about the crushed glands is examined under a one-sixth objective for the slender, glistening, rod-shaped malaria parasites (called sporozoites in this stage). (See 5 in Chart 3.)

There are methods of staining these specimens to bring out in more detail the characteristics of the malaria parasites. But it is not in the province of this discussion to describe this technique. The above technique is presented only as a field procedure to determine the number of infected mosquitoes.

Key to the Genera of North American Mosquitoes and Description of Some Important Species

The following key is for the purpose of differentiating the genera of adult mosquitoes. For a detailed key to all species the sanitarian may consult more specialized literature.

Key to Genera of Adult Mosquitoes (See Fig. 4.)

1. Mosquitoes having long palpi in both sexes. Female palpi are as long as proboscis or nearly so. Absomen is not covered with flat scales. The scutellum is evenly rounded. Wings are usually spotted. Male palpi are long and clubbed at tips. . . . . .Genus Anopheles.

2. Mosquitoes whose females have much shorter palpi than their probosces. Abdomen is covered with flat scales. Wings are unspotted. Male palpi are not clubbed.

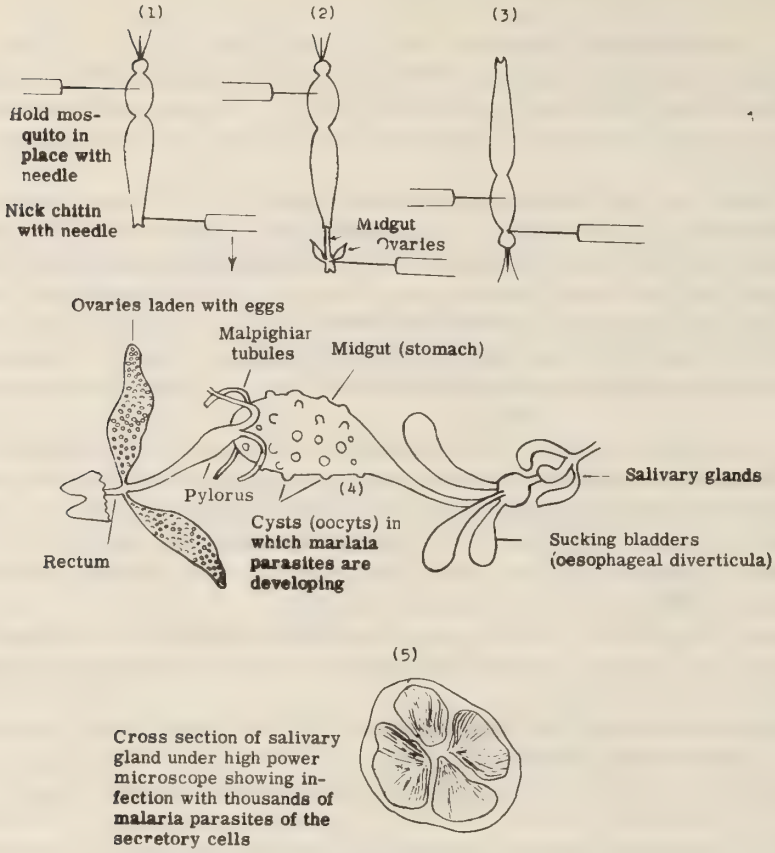
a. Proboscis is rigid, the outer half tapering and sharply curved downward. Very large iridescent mosquitoes with striking appearance. Female palpi are one-half or two thirds as long as proboscis. Second marginal cell is less than half as long as its petiole. Scutellum is evenly rounded and scaled . . . . . Genus Megarhinus.

b. Proboscis is straight or only slightly curved, not tapered. Scutellum is trilobed.

1) Second marginal cell is less than half as long as its petiole. Very small species with lines of bluish or purplish scales on thorax and on base of vein 5, giving an iridescence to the thorax. Palpi are short in both sexes . . . . . .Genus Uranotaenia.

2) Second marginal cell as long as or longer than its petiole. Medium size or large species, but if small, they have no lines of bluish scales on thorax. Tarsi are not ringed with white and mesonotum is without distinct markings (except small white dots in Culex restuans). . . . . .Genus Culex, and Genus Culiseta, and Genus Deinocerites

Chart 3. Technique for Dissection of Mosquito



a) Genera Culex and Culiseta are distinguished from genus Deinocerites in that the former two have antennae that are no longer than the probosces, while in the latter, the antennae are much longer than the probosces.

b) The genus Psorophora is distinguished from the Genera Culex, Culiseta, and Deinocerites in that the tarsi have pale markings or the mesonotum is marked with bicolorous scaling in definite patterns of lines or patches. It is a very large type of mosquito of striking appearance and is known as the gallinippers. The legs are shaggy.

c) The Genera Psorophora, Aedes, Mansonia, Orthopodomyia, Wyeomyia are distinguished from the genera Culex (except Culex bahamensis and Culex tarsalis), Culiseta and Deinocerites in that the tarsi of the former have pale markings or the mesonotum is marked with bicolorous scaling in definite patterns of lines or patches.

d) The genus Psorophora is distinguished by its very large size and shaggy legs.

e) The genus Mansonia is differentiated further by the characteristics of ringed tarsi and proboscis. But these characteristics are also found in Culex bahamensis and Culex tarsalis, in the Aedes taeniorhynchus group and in Psorophora (Grabhamia) group.

f) The characteristic of tarsal rings or bands but without ringed proboscis distinguishes the genera Orthopodomyia and Wyeomyia, also part of the Psorophora (Janthinosoma) group, and some of the genus Aedes (aegypti, vexans, stimulans, grossbecki, dorsalis, canadenses, and atropalpus.)

1. The Genus Orthopodomyia is further distinguished from the Genus Wyeomyia in that the former is a medium size mosquito and the latter is very small. The mesonotum of the former has a vestiture of narrow-curved or hairlike scales, while the mesonotum of the latter is covered with broad, appressed, dark scales.

2. The Genus Orthopodomyia is distinguished from the species Aedes aegypti in that the mesonotum of the former has four long silvery lines and four short lines posteriorly not shaped into a lyre and the wing scales are broad and mixed with white, while the latter has four silvery lines on thorax, the outer pair curved to form a lyre and the outstanding wing scales are narrow and dark.

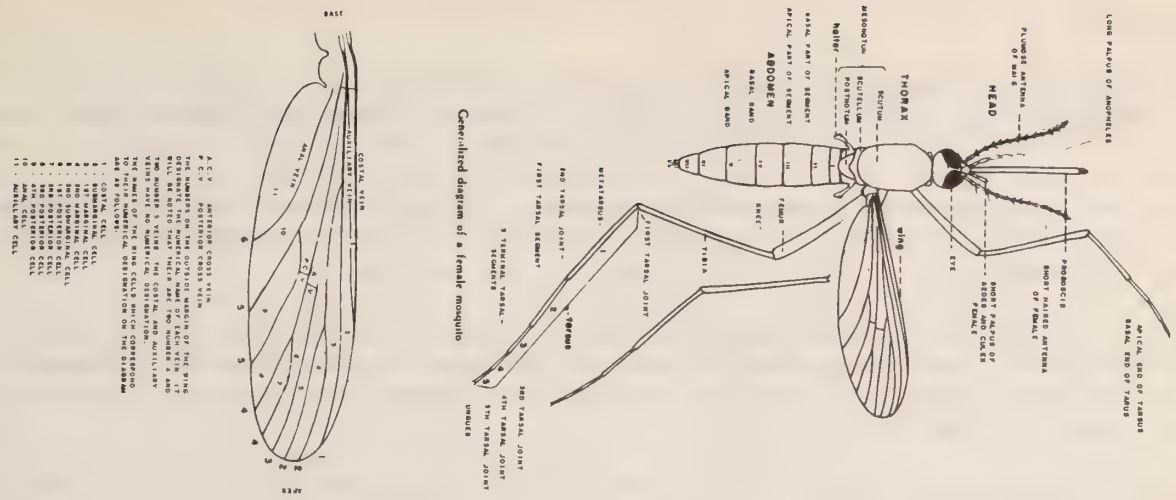


Fig. 4 Anatomical Parts of Adult Mosquito Important in Identification

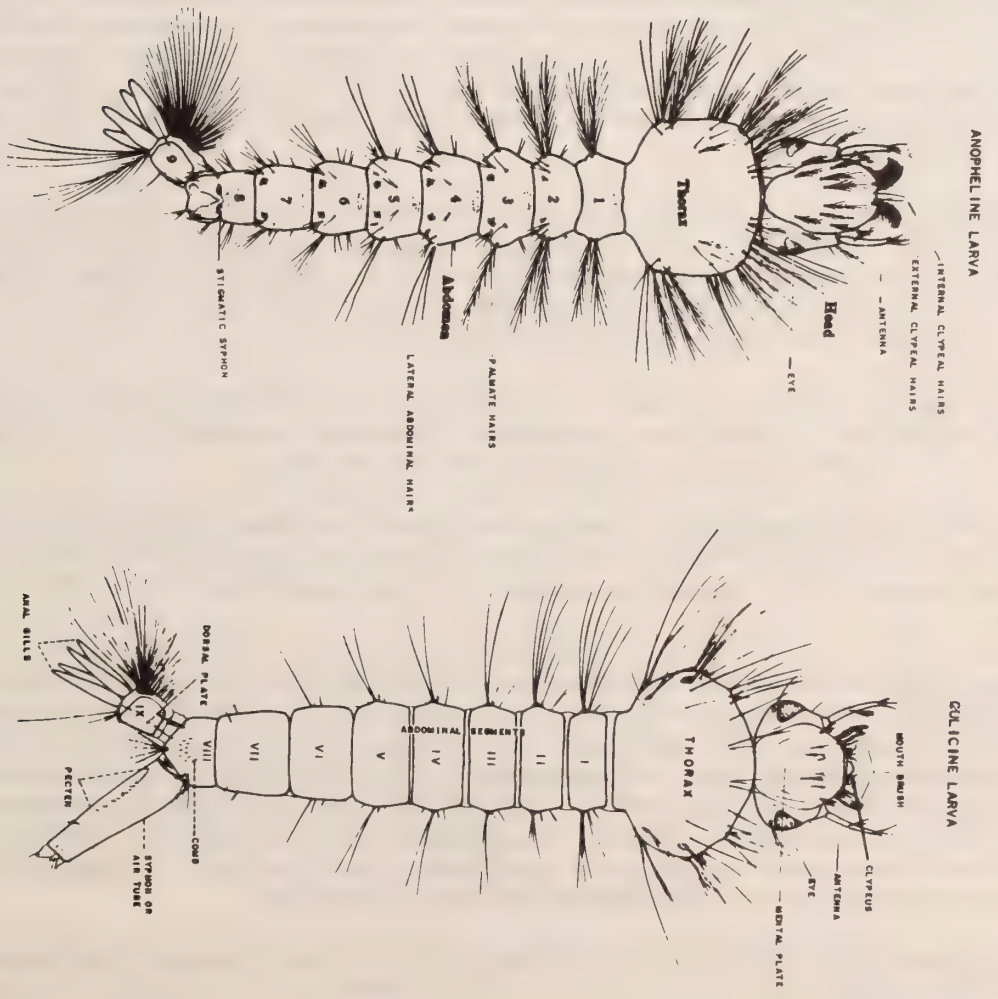


Fig. 5 Anatomical Parts of Mosquito Larva Important in Identification

g) The characteristics of unbanded tarsi and proboscis but having thoracic markings belong to such Aedes as infirmatus, triseriatus, dupreei, atlanticus, tormentor, trivittatus, sticticus, and thibaulti.

Description of Important North American Anopheles Mosquitoes (See Figs. 6, 7, 8)

Anopheles crucians, bradleyi, and georgianus comprise Group One. Wings of these mosquitoes have one prominent pale area of scales on the front margin near the tip. One striking characteristic of all three species is the presence of three black spots on the sixth or last vein of each wing. These dark spots are separated by pale areas. Palpi of all three species are banded with white, and the last segment is entirely white. Separation of the three species is practical only in the larval stage.

Anopheles punctipennis is a Group Two mosquito. It has two pale-colored areas of scales on the front margin of each wing. Both the tarsi and the palps are dark-colored in this species. The sixth or last vein of each wing is covered with dark-colored scales at each end and light-colored scales in the central areas.

Anopheles albimanus is another Group Two mosquito. Each wing has two prominent pale areas along its front border. An outstanding characteristic of this species is the broad white banding of the hind tarsi. The segments of the hind tarsi are entirely white except for the dark bands of scales at the bases of the first and last segments. The second and third segments of the palps have apical white scaling. The apical segment is entirely white.

Anopheles pseudopunctipennis is also a Group Two mosquito. Adult females of this species resemble those of Anopheles punctipennis with their two prominent pale areas on the front border of each wing, but the pattern of scales on the wings is different. In addition, there is a fringe of white, hair like scales at the end of each wing vein. Unlike Anopheles punctipennis the palps of Anopheles pseudopunctipennis are white banded. In addition, the tip of each palp is covered with white, hair-like scales.

Anopheles franciscanus is a Group Two mosquito which resembles Anopheles pseudopunctipennis very closely. However, the palps of female Anopheles franciscanus are tipped with dark-colored, hair-like scales, instead of white as is true for Anopheles pseudopunctipennis. In addition, the stem of the fourth vein of Anopheles franciscanus frequently is dark-scaled instead of white as is generally found in Anopheles pseudopunctipennis.

Mosquitoes in Group Three have generally clear or unspotted wings with the black or brown-colored scales distributed evenly over the veins. This group consists of only two species which vary considerably in size, Anopheles barberi being the smaller.

The bristles of Anopheles barberi females are longer than those of Anopheles atropos. These bristles are about one-third as long as the thorax is wide, and vary in color from a golden brown to a very dark brown. They tend to be arranged in three longitudinal rows. Palps and legs are dark-scaled.

Anopheles atropos is the other mosquito found in Group Three. It is a larger species than Anopheles barberi, and has shorter bristles on the thorax. The bristles vary in color from dark brown to black. In general, this species is a very dark, almost black mosquito. Generally the scales are distributed evenly over the wing veins of Anopheles atropos, but occasionally specimens show faint dark spots on the wings. Wings of such specimens might be easily confused with those of Group Four mosquitoes. However, an examination for knee spots should determine whether or not the specimen belongs in Group Three or in Group Four. Anopheles atropos lacks the white knee spots found on mosquitoes belonging to Group Four.

Anopheles walkeri is a mosquito from Group Four, with four more-or-less distinct spots on each wing. Usually these spots are less distinct than those of other Group Four mosquitoes. Anopheles walkeri can be separated from all other Group Four mosquitoes by the presence of narrow white bands of scales on the palps. The others in this group have entirely dark-colored palps. The presence of white knee spots and the golden color of the halteres readily distinguish adult Anopheles walkeri from the Group Three mosquito Anopheles atropos which sometimes

shows faint dark spots on its wings. The fringe on the margin of the wings is entirely dark.

Anopheles occidentalis is another mosquito belonging to Group Four. The fringe at the tip of each wing varies from a silver to a light lemon or copper color. This colored fringe distinguishes Anopheles occidentalis from other Group Four mosquitoes. The palps are covered with dark brown or black scales. The black spots on the wings are usually well defined, unless the scales forming the spots be faded or have been rubbed off the mosquito.

Anopheles quadrimaculatus and Anopheles freeborni are Group Four mosquitoes which cannot be distinguished from each other in the adult stage. They are separated from Anopheles occidentalis by the color of the fringe of scales near the tip of each wing. These scales are uniformly dark-colored in Anopheles quadrimaculatus and Anopheles freeborni as contrasted with the colored fringe present at the tip of the wing in Anopheles occidentalis. Palps in both species are entirely dark-colored. The dark-colored, unbanded palps and the dark-colored halters separate the two species from Anopheles walkeri. However, females of Anopheles quadrimaculatus and Anopheles freeborni resemble each other so closely that the two species are separated only in the larval stages or after an examination of male specimens. In general, specimens from east of the Rocky Mountains are Anopheles quadrimaculatus, while those from west of the Rockies are Anopheles freeborni.

For description of other North American mosquitoes see Chart 1

Use of Key for Identification of Anopheles Mosquitoes

All classes of insects, just like all groups of living things, have certain characteristics which are common within each group and others which are different and distinguish each group one from the other. It is upon the basis of these similarities and the differences among various types of organisms that makes classification possible. Thus, all mosquitoes have certain generally similar characteristics which distinguish one genus from another and one species from another. Since it is almost impossible for one individual to keep all these similarities and dissimilarities in his mind, "keys" have been worked out which are simple guides for the student in identifying and classifying various organisms. The accompanying key for adult Anopheles mosquitoes is just such a key. It gives a step by step description of those characteristics of the mosquitoes by which one species may be distinguished from another. The series of steps in the key are arranged so that the first step begins with some general characteristics and is followed by other steps describing in progressive sequence the more specific characteristics which distinguish one species from another. For example: Most of the North American adult Anopheles mosquitoes have spotted wings, but some have characteristic pale spots and others have characteristic dark spots, (Anopheles albimanus has certain pale spots which distinguish it from a group of other Anopheles mosquitoes which have certain dark spots or no spots at all). Then, among the group with charactertistic dark spots, some have more and some have less spots than others, (Anopheles crucians has 3 characteristic dark spots, Anopheles quadrimaculatus has 4 characteristic dark spots.)

The differentiation becomes greater and greater as one follows the key step by step. The same process of differentiation is carried out in relation to other identifying characteristics of the mosquito, such as the legs, the palpi, the abdominal segments, etc. While a mosquito may have less specific distinguishing characteristics for one part of the body, it may have very specific distinguishing characteristics for another part of the body (Anopheles quadrimaculatus has 4 dark spots on its wings and so has Anopheles occidentalis, but A. quadrimaculatus has a dark wing fringe while Anopheles occidentalis has a silvery or golden fringe at the wing tip).

Key to Adult Females of Anopheles

1. Tarsi black; wing rarely with more than two pale spots on costal margin 2
   Tarsi, particularly those of hind leg, marked with white; wing with four or more pale spots on costal margin . . . . . A. albimanus
2. Wing with areas of pale scales on veins 3
   Wing with only dark scales on veins (except for pale apical area in fringe of occidentalis) 6

3. Wing with two or more distinct pale areas on coastal margin; vein 6 with one or two areas of dark scales 4
Wing with only one pale area on costal margin, this at apex; vein 6 with three black spots . . . . . A. crucians
A. bradleyi
A. georgianus

4. Wing vein 3 entirely dark; vein 6 with a dark spot at each end, white in the middle, palpus not banded . . . . . A. punctipennis
Wing vein 3 mostly pale scaled, dark scales only on basal third and near apex; vein 6 with a single dark area apically; palpus banded 5

5. Wing vein 4 pale before fork; palpus with terminal segment white scaled . . . . . A. pseudopunctipennis
Wing vein 4 dark before fork; palpus with apical portion of terminal segment black scaled . . . . . A. franciscanus

6. Wing with more or less distinct spots of dark scales, or palpus and legs with white rings; mesonotal hairs comparatively short 7
Wing not spotted; palpus and legs dark; mesonotal hairs about one-half as long as width of mesonotum; (small species) . . . . . A. barberi

7. Palpus with dark scales (faint white rings sometimes present at base of apical segment of atropos) 8
Palpus with narrow, but usually distinct, white ring at apex of terminal segment; (legs with pale kneespots) . . . . . A. walkeri

8. Wing with distinct dark spots 9
Wing with indistinct spots; (legs without pale kneespots; dark species) . . . . . A. atropos

9. Wing with fringe entirely dark 10
Wing fringe with patch of silvery or golden scales; dark wing spots very pronounced . . . . . A. occidentalis

10. Rocky Mountains east . . . . . A. quadrimaculatus
Rocky Mountains west . . . . . A. freeborni
Valley of Mexico . . . . . A. aztecus

Developing Sanitary Control Regulations for Mosquito Borne Diseases

Where mosquito borne diseases are local problems their control is best effected by the adoption of regulations making certain sanitary measures mandatory upon the population and the local government. The following outline should be the basis for developing such sanitary control regulations:

Urban and Suburban Mosquito Control

Water liable to breed mosquitoes in or near cities, towns, villages or hamlets, should be protected, stored, covered or treated, in the manner following:

a. Cisterns should be provided with wood or metal covers, and all openings whether on top or sides, larger than 1/18 of an inch, should be screened with wire mesh not less than 18 strands to the inch each way; and the pipes leading to or from the cisterns should be screened in such a way as to prevent the entrance of mosquitoes.

b. Tanks and barrels should be screened in like manner, or the water should be covered with coal oil or crude petroleum.

c. Buckets, or other containers, holding water for use in case of fire, should contain solutions of copper, borax, or other chemical inhibitory to mosquito development.

d. All water containers in hotels, boarding houses and public buildings should be emptied at least once a week and the containers scrubbed and dried before refilling, unless the water be chemically treated as above described in item c.

e. Water in fountains, basins, urns, etc., in public parks, cemeteries and residential sites, and in ponds, barrow pits or other depressions or excavations in such areas liable to hold water not easily drained, must be cleared and freed from debris and vegetation, and then may be stocked with mosquito larvae feeding fish, or screened or oiled.

f. In the event of an outbreak of yellow fever, or dengue, the health officer might, in addition to these items have cisterns or drinking water containers covered with paraffin dissolved in gasoline, and other containers of water covered with coal oil or crude petroleum.

g. All suspicious cases of fever should be protected from the bites of mosquitoes until, and unless, they be found not to be mosquito-borne diseases; and if found to be mosquito-borne, protection should be continued until the infective stage is passed.

Impounded Waters

Any person proposing to impound water, raise the level of existing impounded water, or re-impound water in areas where previous impoundage has been discontinued for one or more seasons, should, prior to the institution of any construction activities, make application to the health department and receive a written permit for impoundage construction. All work should be supervised by a representative from the health department, and regular inspections made to assure adherence to sanitary measures. Any changes made in relation to the impounded water should be approved by the health department.

a. In an area to be occupied by a reservoir, its branches, bights and indentations, all brush, undergrowth, logs, stumps and similar objects which, if not removed, would float or collect floatage on the surface of the impounded water, and all of the above material which is lying on the ground or remaining in original or new position, which would probably cause floatage to gather, and thus constitute conditions favorable to the protection of larvae of mosquitoes capable of conveying malaria, should be removed, burned, or otherwise satisfactorily disposed of prior to the impounding of the water.

The above does not include grass, vegetation, brush, trees, stumps, etc., which will be permanently and completely submerged at the time of low water and which are, therefore, not of sanitary importance.

b. All brush and undergrowth which would pierce the surface at low water level should be cut off at least one foot (1') below such water level, to prevent the collection and anchorage of any possible floatage, rafts, etc.

c. The shore line should be cleared of all brush and undergrowth, and the like, so as to prevent the collection of drift and floatage along the shore. This clearing should extent from minimum low water level to a line not less than fifteen (15') feet, horizontally, beyond high water level, unless a vertical distance above high water of five (5') feet occurs in a lesser horizontal distance, but in no case should the horizontal distance be less than five (5') feet.

d. Sound live trees of species which will survive when their roots are permanently submerged may be left standing in areas to be flooded; and sound live trees may be left standing on the banks where they are not likely to fall into the water. All other trees should be removed.

Small ponds, or other waters, suitable for the propagation of Gambusia (top minnows) in sufficient numbers to stock the reservoirs, its branches, bights and indentations for effective mosquito control, should be provided at the time of initial construction on the project.

All depressions which will be filled with water from the reservoir, at the time of maximum water level, in which water might be retained at lower stages of the water level in the reservoir, thus forming separate pools, should be connected with the normal body of the reservoir, or any of its branches, by a ditch or culvert which will permit complete drainage and the entrance of top feeding minnows.

Insofar as practicable, the water level in the reservoir should be fixed so as to reduce to a minimum shallow submerged areas on which aquatic plants will grow and reach the surface of the water.

In the designing and construction of the impoundage project, flashboards or other means should be provided for controlled fluctuation of the water level at any season of the year in the manner and amount as specified by the health department.

In the designing and construction of the impoundage project, bottom drains or other means should be provided which will permit removal of the impounded water.

No filling or impounding should be started during the malaria-carrying-mosquito breeding season, namely: May to October, inclusive, unless otherwise authorized by the health department.

Maintenance of an Impounding Project:

a. During the mosquito breeding season the permit-holder should regularly and frequently remove all flotage and floating debris in the reservoir, its branches, bights and indentations, which are producing mosquitoes within one (1) mile of human habitation.

b. A clear shore line should be maintained during the mosquito breeding season by holding the water level two (2') feet or more above normal during the winter months, and by frequent variations at other times; or where these measures are inadequate, by the removal of all trees, brush, undergrowths, logs, stumps and flotage from such portions of the shore line as may be designated by the health department, for a distance of not more than fifteen (15') feet back from normal high water level, and/or the poisoning of stumps, and application of herbicides.

c. Prompt and proper measures should be taken to prevent the growth of cattails, bulrushes, and other aquatic, or semi-aquatic, vegetation which offers protection to mosquito larvae from their aquatic enemies.

d. Where these various methods of larvae control are ineffective or insufficient, larviciding should be carried on as may be directed by the health department.

Newly created impounded waters should not be stocked with game fish (trout, bass or pike) without written permission from the health department.

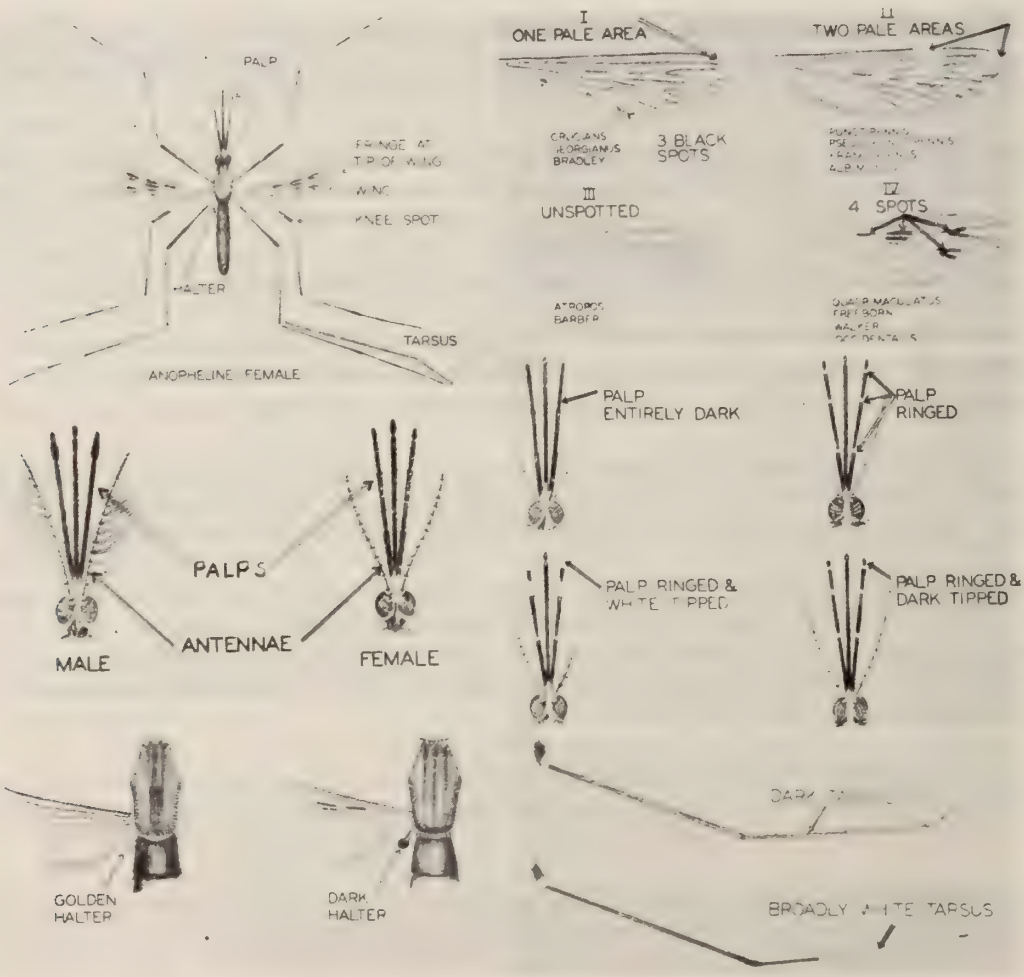


Fig. 6

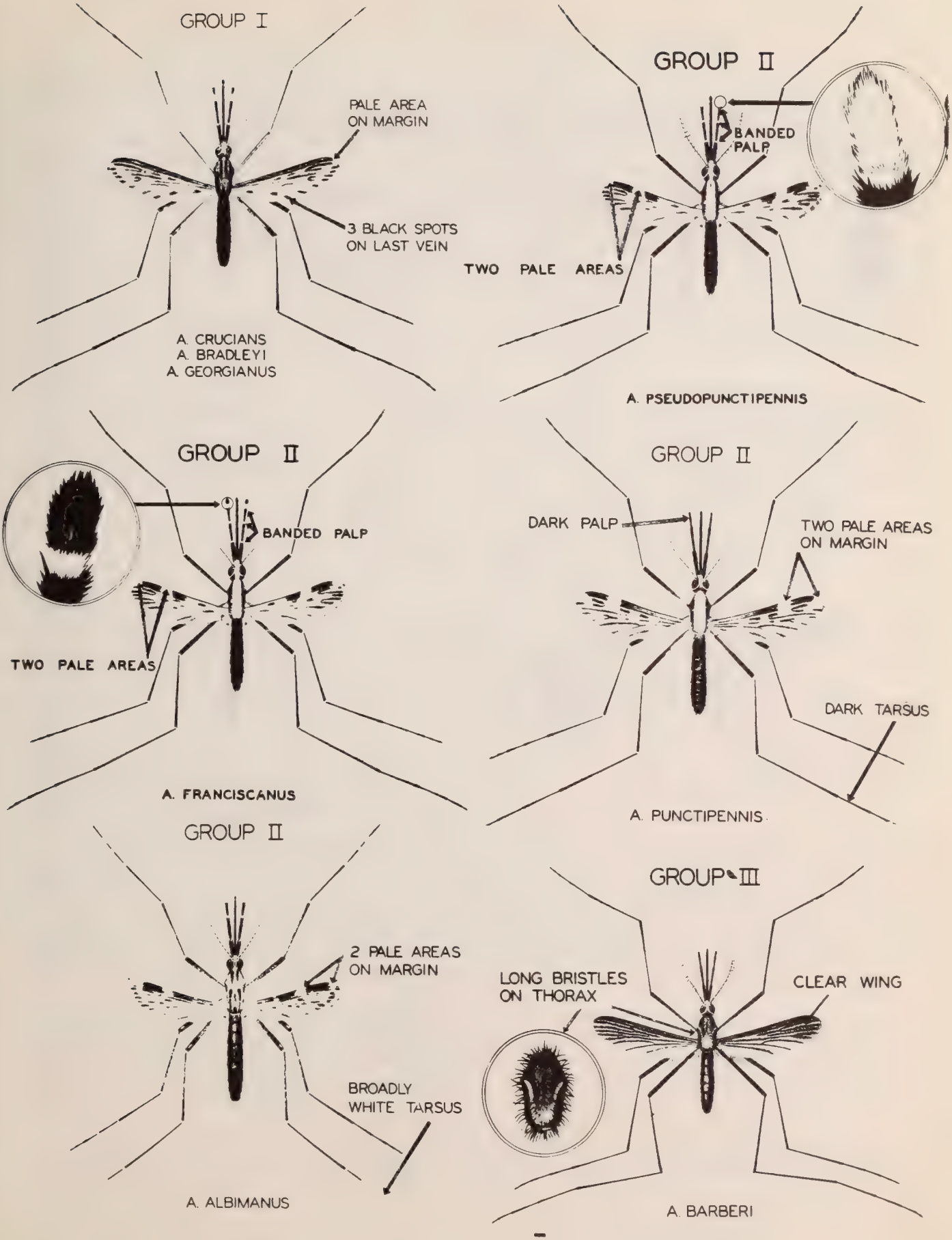

GROUP I
PALE AREA ON MARGIN
3 BLACK SPOTS ON LAST VEIN
A. CRUCIANS
A. BRADLEYI
A. GEORGIANUS
GROUP II
BANDED PALP
TWO PALE AREAS
A. PSEUDOPUNCTIPENNIS
GROUP II
BANDED PALP
TWO PALE AREAS
A. FRANCISCANUS
GROUP II
DARK PALP
TWO PALE AREAS ON MARGIN
DARK TARSUS
A. PUNCTIPENNIS
GROUP II
2 PALE AREAS ON MARGIN
BROADLY WHITE TARSUS
A. ALBIMANUS
GROUP III
LONG BRISTLES ON THORAX
CLEAR WING
A. BARBERI

Fig. 7

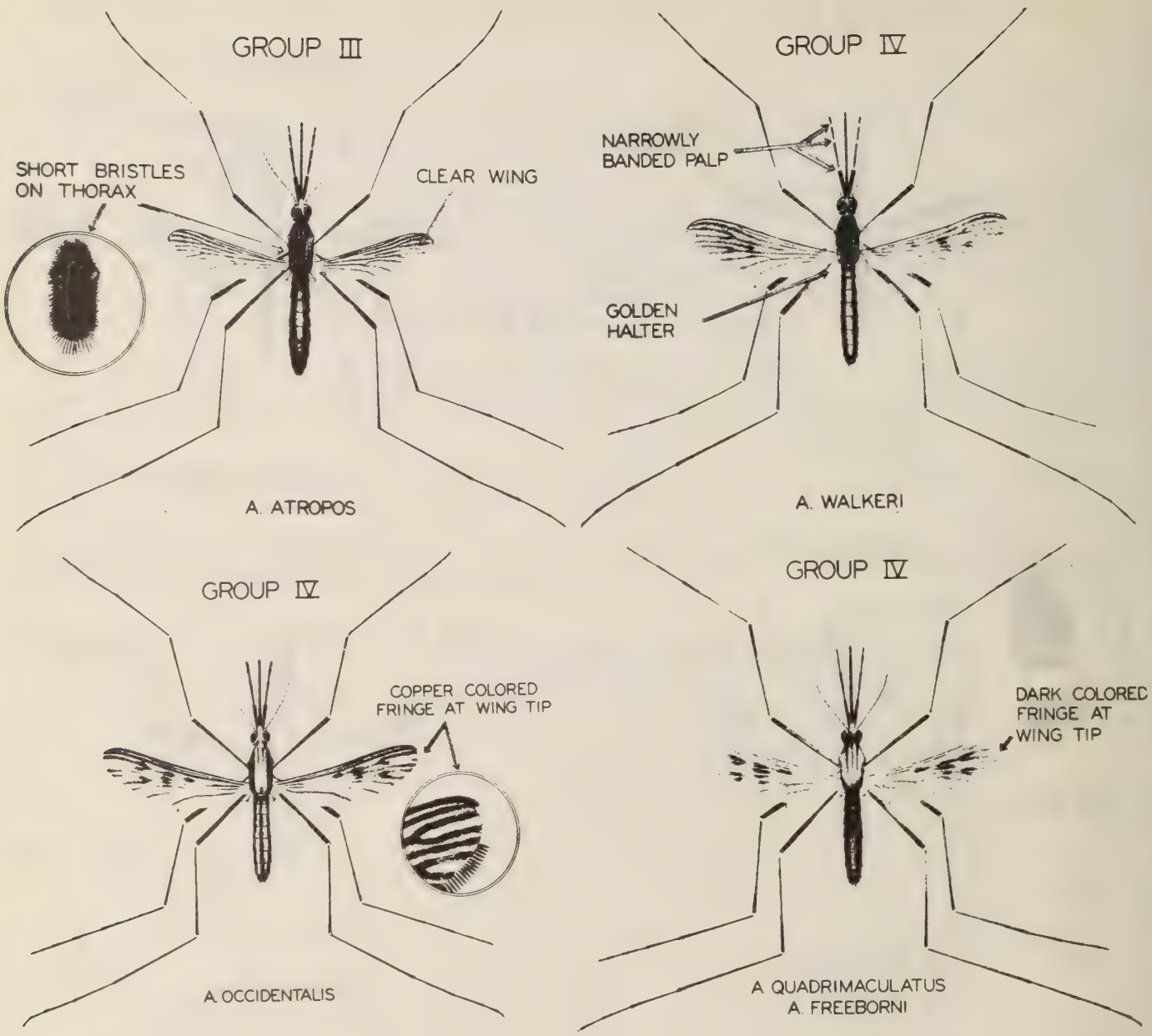

GROUP III
SHORT BRISTLES ON THORAX
CLEAR WING
A. ATROPOS
GROUP IV
NARROWLY BANDED PALP
GOLDEN HALTER
A. WALKERI
GROUP IV
COPPER COLORED FRINGE AT WING TIP
A. OCCIDENTALIS
GROUP IV
DARK COLORED FRINGE AT WING TIP
A. QUADRIMACULATUS
A. FREEBORNI

Fig. 8

Chapter XXVII

Housing for Health

General Considerations

Although the construction of houses and neighborhood and community planning are functions mainly of the engineers, architects and social scientists, the hygiene of housing is, in a very proper sense, the function of the sanitarian; nor are the sanitarian's functions exempt from neighborhood and community planning since he should also be, in a certain sense, a social scientist, and such planning cannot be satisfactorily achieved without the hygienic sense about the environment which a competent sanitarian possesses. The inspection and evaluation of the hygiene of houses and neighborhoods is a function in which every sanitarian must become proficient. Every aspect of the sanitarian's knowledge and ingenuity must be brought to bear in dealing with the hygiene of housing. One of the most important aspects of environmental hygiene in which the sanitarian should become adept is in making housing surveys for the purpose of planning for slum clearance and neighborhood rehabilitation. This chapter is particularly aimed in that direction. It is hoped that the sanitarian's interest in this field will step up the slow rate of progress being made in the hygienic housing of our population.

The intimate relationship between poor housing, poor health and low economic status has long been known and accepted in principle by public health workers. The modern public health movement nourished itself on the struggle against poor housing and environmental hygiene in the prisons (John Howard and the prison reforms in England in 1774), in the factories (beginning with the first British factory act in 1802), and in the slums (Edwin Chadwick's report in 1834 on the "Sanitary Conditions of the Labouring Population in England"). In 1873, Max von Pettenkofer, a pioneer in modern environmental hygiene, delivered a lecture on "The Value of Health to a City" in which he not only discussed the importance of the problem in modern times but also outlined some of the historical highlights as far back as the early Roman period.

Stephens Smith, the spearhead in organizing the American Public Health Association, fought his public health campaign on the basis of slum riddance. Throughout the history of the American public health movement, the problem of housing has played a prominent part. It can be said with confidence that the mortality and morbidity rates (including accident rates) vary inversely with the "real value" of incomes of families and with the sanitary housing facilities which these incomes are able to purchase on the open market. Studies in the large cities in the United States show that, it is an illusion to believe that slum houses really bring the lowest rents. It has been conclusively shown that, although the rent per individual may be low, the crowding of individuals into slum houses and the paucity of facilities and comfort that one derives from such housing make slum houses the most expensive rental units in the country.

The exact effect that housing has on health is not known. There undoubtedly are definite direct relationships between the two such as determine home accident rates and the rate for certain behavior disorders. The economic factor, however, appears to be basic to this relationship, since the economic factor will determine the type of house and neighborhood in which a family will live and will also determine the ability of the family to buy food, to get an education, to buy medical care and the like which so fundamentally influence the health of a family. The housing conditions of a family, then, can be taken as the index of the economic status of that family.

So intimately related are housing and economic status, that no matter which of these factors are altered the other is affected. To raise the economic level of the people would soon be followed by the development of better housing for them. To guarantee them the right to good housing would itself be a step in raising their economic level. But fundamentally the economic status is the more basic of the two factors.

A number of studies are available that show the intimate relationship between housing and health and how the economic factor is basic to both. The following epidemiological data adds weight to the above thesis:

1. Crowding is a most significant factor in the spread of most communicable diseases. In most poor housing areas crowding[1] is a primary feature. (See Tables 1, 2, and 3.)

2. Poor excreta disposal and water supply are the most important factors in the spread of epidemic diseases of gastrointestinal nature. But poor disposal of excreta and poor water supply are certainly the major housing problems in poor housing areas.

3. Structural defects of houses are a major cause of accidents. Accident rates are highest in poor housing areas. (See Table 7.)

4. Poor heating is an important cause of exposure. Heating is undoubtedly poorest in the areas of low grade housing.

5. Stresses of crowding and discomfort tax the relationship between people so exposed to a complicated chain of mental and emotional events that result in behavior disturbances. The behavior disorder rates increase as the adequacy of housing decreases. (See Table 5.)

Table 1. * Percentage of Dwelling Units with Selected Deficiencies Inhabited by White and Negroes (in the slum area of this survey 20% of the dwelling units were occupied by Negroes)

Types of Deficiencies	% of Deficiencies in Dwelling Units inhabited by whites	% of Deficiencies in Dwelling Units inhabited by negroes
Toilet outside dwelling unit	18	53
Toilet shared by 2 or more dwelling units	12	50
Toilet without window to outside air	14	37
Toilet without artificial light	7	40
Toilet in poor sanitary condition	7	61
No bathing facilities	29	61
Bathing facilities outside dwelling unit	0.5	7.5
Piped cold water only	16	52
No piped water	0	3
No refrigeration	2	31
Rat infestation	8	64
Fire hazard	28	90

The above table shows the very disproportionate amount of deficiencies between Negro and White inhabited dwellings. The survey also showed that for the same amount of rent paid, the Negro lived under housing conditions 1 1/2 to 2 1/2 times as bad as the White.

Table 2* Percentage of Dwellings with Selected Deficiencies in Various Types of Structures

Types of Deficiencies	% of Structures with Mixed Business and Residential Uses having Deficiencies			% of Structures with Purely Residential Uses Having Deficiencies		
	Housing 1 Family	Housing 2 Families	Housing 3 or more Families	Housing 1 Family	Housing 2 Families	Housing 3 or More Families
Toilet outside dwelling unit	00	22	57	4	11	21
No bathing facilities	11	33	53	48	29	32
Toilet shared by 2 or more dwelling units	00	8	50	00	5	18
Rat Infestation	56	31	54	00	2	15
Toilet without window to outside air	00	51	36	00	3	15
Fire hazard	44	47	72	22	32	38
Toilet in poor condition	00	17	54	7	4	14
% of structures in need of repair or beyond repair	22	51	57	32	23	25

This table reveals that the physical deficiencies are far worse in buildings with mixed residential and business uses than in the purely residential buildings.

*Compiled from Report of the Subcommittee on Appraisal of Residential Areas, Committee on Hygiene of Housing, A. P. H. A., Public Health Reports, April 3, 1942, p. 485.

1. Housing for Health, Papers presented during the auspices of the Committee on Hygiene of Housing of the A. P. H. A.; the Science Press Printing Co., 1941.

Table 3. Death Rates for Specific Causes of Death[1], Native White, by Sex, Cause, and Economic Level, Chicago, 1928-1932

Economic Area[3]	Infections & Parasites	Cancer & Tumors	Rheumatic & Endocrine	Blood	Nervous System	Circulatory	Respiratory	Digestive	Genito-urinary	Child birth[2]	Accidents
MALE											
I	2.013	0.933	0.406	0.465	0.498	4.029	0.691	1.693	0.895		1.705
II	1.466	0.832	0.340	0.403	0.499	3.406	0.420	1.386	0.561		1.309
III	1.212	0.779	0.286	0.375	0.466	2.890	0.403	1.301	0.677		1.055
IV	0.898	0.789	0.316	0.419	0.493	2.663	0.296	1.140	0.623		0.950
V	0.638	0.775	0.323	0.350	0.571	2.567	0.328	1.073	0.562		0.849
FEMALE											
I	1.320	1.135	0.619	0.706	0.494	3.837	0.504	1.542	0.758	0.364	0.545
II	1.056	1.070	0.562	0.387	0.458	2.999	0.361	1.374	0.674	0.284	0.495
III	0.928	1.086	0.560	0.434	0.464	2.578	0.282	1.331	0.658	0.261	0.409
IV	0.772	1.055	0.417	0.408	0.369	2.283	0.252	1.107	0.590	0.211	0.371
V	0.821	0.742	0.257	0.220	0.413	1.621	0.381	0.819	0.367	0.203	0.309

Death Rates for Specific Causes of Death[1], Negro, by Sex, Cause, and Economic Level, Chicago, 1928-1932

Table 4

Economic Area[3]	Infections & Parasites	Cancer & Tumors	Rheumatic & Endocrine	Blood	Nervous System	Circulatory	Respiratory	Digestive	Genito-urinary	Child birth[2]	Accidents
MALE											
I	6.075	0.303	0.379	0.484	0.819	6.958	1.269	2.389	1.193		3.207
II	5.062	0.738	0.362	0.545	0.711	6.169	1.358	2.785	1.193		2.439
III	3.566	0.642	0.347	0.524	0.566	4.230	0.856	1.797	1.195		2.267
IV	3.208	0.989	0.242	0.370	0.649	4.004	0.858	2.384	0.981		1.595
V											
FEMALE											
I	4.815	1.409	0.654	0.809	0.981	6.527	1.049	2.305	1.303	0.566	0.984
II	2.324	1.175	0.687	0.883	0.830	5.565	0.926	2.419	1.231	0.540	0.760
III	2.754	1.344	0.514	0.771	0.731	4.378	0.590	1.805	1.148	0.375	0.802
IV	2.442	1.470	0.474	0.537	0.868	3.483	0.445	1.671	0.835	0.352	0.503
V											

1 Rates per 1000, standardized for age.
2 Rates per 1000 women 15-44 years.
3 As the index of economic status, the median rental in each local census tract was employed. In this study, those ranging:
1) Under $30 rent per month = Area I
2) Between $30 & 44.99 per month = Area II
3) Between $45 & 59.99 per month = Area III
4) Between $60 & 74.99 per month = Area IV
5) Over $75 per month = Area V

From- Economic Differentials in Causes of Death in Chicago, 1928-32 L. C. Coombs, Medical Care, Vol. No. 3., p. 246.

Table 5. Various Social and Economic Factors Related to Frequency of Mental Disorders Occuring Among 28,763 Cases Institutionalized (State and Private) in Chicago, 1922-34

(a) Type of Area		Percent of Homes Owned	Percent of Single Dwellings	(b) Schooling Index	Percent Foreign Born	Restaurants per 1,000 population	Infant Mortality	Crude Death Rates	Rates per 100,000 population between 15 and 16 years: Types of Schizophrenia: Paranoid	Hebephrenic	Catatonic	All types	Manic-Depressive	General Paralysis	Senile Psychosis	Alcoholic Psychosis	Drug Addiction with Psychosis
Economically and socially most stable	1.	49.5	47.3	42.5	15.9	0.54	45.8	8.1	5.8	8.1	5.4	20.7	5.9	6.8	32.9	3.7	0.6
	2.	53.1	56.2	30.9	22.6	0.69	54.7	8.2	6.7	12.2	7.1	26.4	4.8	7.5	30.3	10.1	0.5
	3.	37.6	23.5	41.2	19.8	0.74	44.6	8.9	7.2	10.7	6.9	26.9	7.0	8.5	35.6	4.1	1.1
	4.	37.4	19.4	25.7	23.3	0.81	58.1	9.8	7.6	15.2	8.2	32.5	5.8	10.7	43.9	11.3	0.7
	5.	19.3	10.2	56.4	17.2	1.06	38.9	9.0	7.1	8.8	4.8	23.4	9.3	9.9	36.0	3.6	1.2
	6.	6.6	5.0	67.0	14.6	1.95	43.8	9.6	8.9	10.0	5.0	27.1	10.3	13.7	33.0	4.8	3.9
Fringe of slum	7.	26.5	11.6	27.3	25.6	1.16	61.1	10.4	10.0	17.2	5.9	38.4	7.0	11.1	46.6	17.5	1.1
	8.	22.1	5.3	31.2	38.2	0.91	47.8	8.3	9.2	20.9	12.0	44.6	9.1	7.8	31.8	6.6	1.1
Slum	9.	11.2	8.3	30.2	2.3	1.27	81.4	17.1	10.0	24.6	16.0	50.4	5.8	35.3	106.8	19.6	2.8
	10.	19.6	7.5	21.3	27.4	1.82	68.7	12.9	15.9	25.1	13.0	54.9	7.4	21.8	66.9	29.2	3.5
	11.	7.6	6.4	33.9	20.4	14.56	133.3	19.7	33.8	42.7	9.4	93.3	11.1	48.1	104.3	38.6	36.4

Data compiled from "Mental Disorders in Urban Areas," Faris and Dunham.

(a) Types of Areas.

Area 1. Stable, well-to-do population living in single homes (predominately) and two-flat houses with rentals $50 and higher.
Area 2. Stable economic and social status, living in single homes (predominately) and two-flat houses with rentals $50 and less.
Area 3. Stable economic and social status, living in two-flat house (predominately) and single houses with rentals $50 and higher.
Area 4. Fairly high stable economic and social status, living in two-flat houses (predominately) and single houses with rentals $50 and less.
Area 5. Apartment-house area of native white population in fairly desirable sections, fairly stable economically and socially.
Area 6. Hotel and apartment-hotel area, with fairly high economic class with some mobility but fair amount of stability.
Area 7. Apartment-house and two-flat houses located on the fringe of the slum areas.
Area 8. Apartment-house area of foreign born with signs of housing deterioration, located on fringe of slums.
Area 9. Apartment-house area of Negroes, very deteriorated housing; slum.
Area 10. Tenement and rooming-house slums.
Area 11. Rooming-house slums in the most deteriorated part of city.

(b) Based on percent of individuals completing various grades of schooling.

Table 6 CONSTRUCTION AND HOUSING
Housing Units - Selected Characteristics, By States: 1960
(Statistical Abstract of the United States 1967)

State	All Housing Units: Total (1,000)	%With all plumbing facilities*: Sound	%With all plumbing facilities*: Deteriorating	%Dilapidated or lacking plumbing facilities	State	All Housing Units: Total (1,000)	%With all plumbing facilities*: Sound	%With all plumbing facilities*: Deteriorating	%Dilapidated or lacking plumbing facilities	State	All Housing Units: Total (1,000)	%With all plumbing facilities*: Sound	%With all plumbing facilities*: Deteriorating	%Dilapidated or lacking plumbing facilities
U.S.	58,326	74.0	7.8	18.2	Iowa	905	69.8	9.2	21.0	Miss.	629	44.5	6.6	48.9
N. Eng.	3,522	78.7	7.6	13.7	Mo.	1,491	65.8	7.3	26.9	W.S. Centr.	5,534	64.8	9.3	25.9
Maine	365	61.2	7.2	31.5	N. Dak.	195	60.6	5.6	33.8	Ark.	587	48.2	7.4	44.4
N.H.	224	72.8	8.7	18.4	S. Dak.	216	61.5	7.6	31.0	La.	978	60.9	8.1	31.0
Vt.	136	68.4	10.7	20.9	Nebr.	473	72.3	9.1	18.6	Okla.	816	66.0	11.2	22.8
Mass.	1,691	81.1	8.0	11.0	Kans.	740	71.9	10.6	17.5	Tex.	3,153	68.8	9.6	21.6
R.I.	287	78.7	6.6	14.7	S. Atl.	8,033	67.2	6.4	26.4	Mount.	2,227	74.9	9.0	16.1
Conn.	819	84.7	6.7	8.6	Del.	144	80.3	6.5	13.2	Mont.	233	68.0	10.1	21.9
Mid. Atl.	11,277	81.2	8.4	10.4	Md.	935	81.4	6.7	11.8	Idaho	224	72.6	10.9	16.5
N.Y.	5,696	81.3	8.9	9.8	D.C.	263	84.9	6.4	8.7	Wyo.	113	71.9	10.5	17.5
N.J.	1,999	85.2	7.0	7.9	Va.	1,169	66.2	5.6	28.2	Colo.	595	76.4	8.2	15.4
Pa.	3,582	78.7	8.5	12.7	W. Va.	574	56.7	9.2	34.1	N. Mex.	282	69.5	8.2	22.3
E.N. Centr.	11,658	77.1	7.8	15.1	N.C.	1,323	57.1	6.4	36.5	Ariz.	416	76.2	8.4	15.4
Ohio	3,041	77.6	8.2	14.2	S.C.	678	54.3	6.4	39.4	Utah	263	81.9	10.1	8.0
Ind.	1,503	73.0	8.4	18.5	Ga.	1,170	58.4	6.7	34.9	Nev.	102	80.9	7.7	11.4
Ill.	3,276	78.0	7.4	14.6	Fla.	1,777	78.3	5.6	16.1	Pacif.	7,331	83.9	7.6	8.5
Mich.	2,549	78.6	8.1	13.2	E.S. Centr.	3,606	53.0	6.7	40.3	Wash.	1,010	78.4	9.8	11.8
Wis.	1,289	75.0	6.9	18.1	Ky.	926	53.4	6.0	40.6	Oreg.	623	76.6	11.1	12.2
W.N. Centr.	5,140	68.6	8.0	23.3	Tenn.	1,084	57.2	7.0	35.8	Calif.	5,466	86.5	6.7	6.8
Minn.	1,119	70.4	6.4	23.1	Ala.	967	53.5	7.1	39.4	Alaska	67	57.7	9.3	32.9
										Hawaii	166	69.6	10.2	20.2

*Includes hot and cold running water inside the structure, and flush toilet and bathtub or shower inside the structure for exclusive use of the people in the unit,

Wolman and Fletcher[2] noted the following housing conditions from a Works Progress Administration survey in 1934-36.

1. 15% of all families living in southwestern United States did not have running water in their houses.
2. 32% of all families in southeastern United States were without private indoor flush toilets.
3. 14% of all dwelling units in the United States needed major repairs, and 2.3% were unfit for use.
4. 20% of all dwelling units in southern United States needed major repairs and 3.4% were unfit for use.
5. 13% of all dwelling units in northeastern United States needed major repairs and 2.3% were unfit for use.
6. In urban communities, 8% of families paid less than $10.00 per month for rent. When broken down into regions, it was found that while 6% of families in northeastern United States paid less than $10.00 for rent, 37% of families in southeastern United States were in this category.

The National Health Survey showed that while about 15% of all dwelling units in the United States had no private indoor flush toilet the number of dwellings lacking this facility in the south among Negroes, was about 6 or 7 times greater than among the Whites. About 80% of Negro dwellings in towns of 100,000 population or less in the south lacked this facility.

Table 7. Home Accidents

Monthly Rental	Home Accidents per 1000 Persons, Disabling 7 days or Longer During 1 Year		
	Rented Multiple Dwellings	Rented Single Dwellings	Owned Dwellings
Under $10	6	5 1/2	
$10 to $20	5	5	
$20 to $30	4	4 1/2	
$30 & Over	3	4	
Value of Dwelling			
Under $1000			7
$1000 to $2000			6
$2000 to $3000			5
$3000 & Over			4 1/2

The 1960 U.S. census showed that almost 20% of the housing in the United States was dilapidated and that in the deep South the figures ranged from about 25 to almost 50%. The non-white population usually had 2 to 3 times more dilapidation than the white population and this was also true for the large metropolitan areas of the United States. Housing is a symptom of the social problems that have become so poignant and eruptive in recent years. The development of a program that will solve the housing problem and prevent it from recurring will also be one that helps solve the social complexities that are creating the social problems.

Since crowding conditions cause diseases to spread more quickly, one would expect that the incidence of childhood diseases would be greater in early childhood (under 5 years of age) than in later childhood (5 to 9 years of age), because the non-immune younger children would become immune as the result of having had such diseases early. Using the disease frequencies of the various common communicable diseases in later childhood as a base of comparison, let us see how much greater the frequencies of those diseases are in early childhood in relation to crowding conditions.

2. The Opportunity for the Engineer in the Field of Housing, American Journal of Public Health, Vol. 33, p. 701, 1943.

The National Health Survey showed that diphtheria frequency in early childhood as compared to later childhood was 45% greater among the population where more than 1 1/2 persons lived per habitable room. On the same basis mumps increased 70%, scarlet fever 80%, German measles 70%, chicken pox 105%, measles 55%, and whooping cough 35%. The increased frequency of the communication of tuberculosis from one person (the "primary" case) to another (secondary case) in the population under 15 years of age where more than 1 1/2 persons lived per habitable room as compared to that where 1 or less persons lived per habitable room was 70%. For the same age group but among persons on relief, the increased frequency of communication was 85%. The increased frequency of communication of tuberculosis among the relief group where more than 1 1/2 persons lived per habitable room over the frequency in that part of the general population where 1 or less persons lived per habitable room was over 200%. The increased frequency of pneumonia in the age group under 15 years of age among the population where more than 1 1/2 persons lived per habitable room as compared to where 1 or less persons lived per habitable room was 88%. The increased frequency of rheumatism in the age group of 25 years and over where more than 1 1/2 persons lived per habitable room as compared to where 1 or less persons lived per habitable room was almost 50%.

Governmental Participation in Housing

The experience in the entire civilized world forcefully predicates the thesis that housing for health can be attainable effectively and efficiently where government is interested and willing to participate in housing programs. The most comprehensive local aspect of such participation is community or city planning where such planning is based on socio-economic interest in the entire population. The highest level of action that we have reached along these lines is the housing project level whereby certain slum areas are cleared and neighborhood housing units erected. Such progress is commendable, but limited scale projects have such drawbacks as:

1) Neighborhood improvement as an isolated phenonemon is usually not thought out as part of an entire community or city plan.

2) Neighborhood housing units usually do not provide quarters for the lowest economic group, and those slightly above the allowable level. This causes a process of slum-shifting to new areas.

3) Neighborhood planning, because it is usually not tied in with an overall plan, develops in spurts and with long, usually too long, intervals between spurts of activity.

Despite the drawbacks involved in neighborhood planning, it is acceptable to public health workers, and we hope it may become a stepping stone to community planning.

In order for government to be able to plan housing for health effectively, it must exert certain controlling influence. The control should be exerted along the channel of providing housing for those who are unable to afford healthful abodes. This requires government subsidy. There is no other effective solution so long as certain levels of the population cannot afford to pay for adequate housing. Another channel where government control should be exerted is in enforcement of various types of codes relating to housing. J. Ihlder [1] describes the functions of various types of codes as follows:

A housing code has to do with dwellings as dwellings. It deals with such matters as light and ventilation, sanitation, room arrangement, protection against fire, vermin control, etc., from the point of view of the occupant of the dwelling.

A building code has to do with buildings as buildings. It deals with materials, equipment, etc., primarily from the point of view of the structural safety.

A sanitary code deals with the unsanitary conditions throughout the community from the point of the public health.

A zoning code has to do with the development and use of private property throughout the community. It divides the community into a series of zones or districts and for each makes specifications as to permitted uses, proportions of lot occupancy, and bulk of building.

Of all the above codes, the housing code is the most difficult to enforce. Every community

1. Housing for Health, p. 51.

needs a building code, but it is well that such a code should not be made law unless there be evidence that the majority of people will support it and that it can be enforced.

Method of Appraising Housing Livability

In a general way, one need not make a survey to know the slum areas, semi-slum areas, and mildly blighted areas in a community. But in order to know precisely the extent of the problem, the economic feasibility of correcting the problem, and the most critical areas where to start, the survey is a valuable tool.

The committee on the Hygiene of Housing, of the American Public Health Association, undertook to develop a method of measuring the quality of housing in urban slums as a result of requests from public health officials to translate the substance of the Committee"s "Basic Principles of Healthful Housing into a Yardstick of Housing Deficiencies." (These "principles" are quoted in full subsequently.)

The advantages of the method evolved are:

1. It adequately evaluates housing deficiencies which may adversely affect health, safety or essential livability.
2. It recognizes and evaluates the neighborhood environment.
3. It utilizes a penalty scoring system that measures total quality and expresses this measurement by a system of numerical scores.
4. It gives a valid quantitative measurement of housing deficiencies.
5. It utilizes well designed forms for collecting data for analysis.
6. It is suitable for execution by the sanitarians of a health department or by personnel available among the regular staffs of city government departments working under well briefed supervision.
7. It gives results that can be applied to a wide variety of housing and city planning problems.
8. It provides a technical basis for a broad attack by public and private agencies working in cooperation.
9. It provides appraisals at reasonable cost.

The appraisal method briefly consists of the following:

The general concept of the survey method is simple, but a number of the techniques involved are of special character that require some special instruction for competent execution. Cognizant of the need for training supervisors in the use of these techniques, the U.S. Public Health Service has set up a training program for this purpose. It is urged that if any community intends to make such survey, a local engineer or sanitarian be given the opportunity of availing himself of such instruction in order to give competent supervision to such project. The following brief description of the forms which the Committee on the Hygiene of Housing developed is given only for the purpose of acquainting the sanitarian with an overall picture of the character of what is involved in the method.

It needs also to be understood that a housing program of the extent envisaged by the Committee on Hygiene of Housing requires broad participation of a community's agencies in order to be effective. The local health department should not undertake such a project without such broad agency participation. It is best that there be a city planning commission with whom the local health department works in cooperation.

1. Surveying the dwelling units in the particular area. The field schedule used for enumerating the conditions of each dwelling is shown in Fig. 1. A dwelling unit is where an individual family lives. In a house where more than one family lives, the above field schedule is executed for each dwelling unit separately. Another field schedule is executed for each structure and premise regardless of the number of dwelling units therein. This form is shown in Fig. 2. The rooming unit schedule, Fig. 3, is a variant of the dwelling unit schedule adapted to the special characteristics of rooming houses.

2. Surveying the environment. This is based on block and neighborhood evaluation. A Block Map, as shown in Fig. 4 is supplied to the enumerator for each block except those to be wholly

Note for Recall _____ Serial No. U_____

DWELLING UNIT SCHEDULE

Inspection No. _____ Address _____ District No. _____ Block No. _____ Structure No. _____

Floor _____ Part of Floor _____ Unit No. _____ Vacant ☐

D1 KITCHEN FACILITIES

	Yes	No
Installed sink	☐	☐
Installed range (gas, electric, oil, coal, wood)	☐	☐
Refrigerator (mechanical, ice)	☐	☐
Facilities private to unit	☐	☐

D2 TOILET

	Ins. Unit	Outs. Unit	Outs. Struc.	None Avail.
Location	☐	☐	☐	☐

	Flush W.C.	Std. Privy	Other Privy	Flush Hopper
Type	☐	☐	☐	☐

	Private	Shared	Total Units Sharing
Sharing	☐	☐	___

Condition Index	Yes	No
Toilet in working order	☐	☐
Artificial light	☐	☐
Outside window or duct	☐	☐

D3 BATH

	Ins. Unit	Outs. Unit	Outs. Struc.	None Avail.
Location	☐	☐	☐	☐

	Hot Tub	Hot Shower	Cold Tub	Cold Shower
Type	☐	☐	☐	☐

	Private	Shared	Total Units Sharing
Sharing	☐	☐	___

D4 WATER SUPPLY

	Ins. Hot	Ins. Cold	Outs. Unit	Outs. Struc.
	☐	☐	☐	☐

D5 WASHING FACILITIES

	Yes	No
Wash basin in unit	☐	☐
Laundry tub available	☐	☐

D6 DUAL EGRESS

	Yes	No
	☐	☐

D7 ELECTRIC LIGHTING

	Yes	Not Used	None
	☐	☐	☐

D8 CENTRAL HEATING

	Yes	Not Used	None
	☐	☐	☐

D9 ROOM FACILITIES

TOTAL NUMBER OF ROOMS IN UNIT _____

	Kitchen	Liv. Room	Din. Room	Bedrooms 1	2	3	4	5	6	Other			Total (ENTER ABOVE)
Rooms in unit (x)													
Bed capacity (persons)													
Lacking inst. heater (x)													
Lacking window (x)													
Lacking closet (x)													
Dimensions (ft.)	—	—	—	—	—	—	—	—	—	—	—	—	AREA SUB STANDARD

(office entries)

Sleeping rooms (x)													
Area: sleeping (ft.)													
Area: nonsleeping (ft.)													
Area: substandard (x)													ENTER ABOVE

D10 DETERIORATION INDEX

	Deg. 0	Deg. 1	Deg. 2
Walls and Ceilings			
Hole, surface worn	☐	☐	☐
Surface broken, loose	☐	☐	☐
Floors			
Hole, surface worn	☐	☐	☐
Surface broken, loose	☐	☐	☐
Windows			
Broken or defective	☐	☐	☐

D11 INFESTATION INDEX

	Not Evd.	Re-ptd.	Ob-svd.
Rats in unit	☐	☐	☐
Other vermin	☐	☐	☐

D12 SANITARY INDEX

	Not Evd.	Re-ptd.	Ob-svd.
Plumbing leakage	☐	☐	☐
Plumbing obstruction	☐	☐	☐
Water pressure low	☐	☐	☐
Walls or floors damp	☐	☐	☐
Heater hazardous	☐	☐	☐
Wiring hazardous	☐	☐	☐

D13 SIZE OF HOUSEHOLD

Number of occupants: total _____

Number of lodgers _____

Number of basic families _____

D14 RACE OF HOUSEHOLD	White	Nonwht.
	☐	☐

D15 TYPE OF TENURE	Tenant	Owner	Bldg. Empl.
	☐	☐	☐

D16 AMOUNT OF RENT $_____	Mo.	Wk.
	☐	☐

Rent includes:	Furn.	Heat	Neither
	☐	☐	☐

REMARKS (refer to items by number)

_____

_____

_____

_____

SUPPLEMENTARY DESCRIPTION

D13a HOUSEHOLD COMPOSITION AND INCOME

	MALE					FEMALE				
	Age	Rel.	Income $	W.	M.	Age	Rel.	Income $	W.	M.
1						11				
2						12				
3						13				
4						14				
5						15				
6						16				
7						17				
8						18				

(office entries)

D13b FAMILY INCOME PER MONTH $_____

D16a RENT PER ROOM PER MONTH $_____

Inspected by _____ Date _____

Office check _____ Field check _____

DHEW-ATLANTA, GA. *Form DS-2:* Copyright 1944, Committee on the Hygiene of Housing, American Public Health Association

Fig. 1

Assignment No. ____ Serial No. S ____

STRUCTURE SCHEDULE

Address ____ District No. ____ Block No. ____ Structure No. ____

Owner or Agent ____ ☐ Not Available for Occupancy

S1 NUMBER OF UNITS

	Total	Vacant
Dwelling units	—	—
Rooming units	—	—
Business units	—	—

	Total	Nonres.
S2 NUMBER OF STORIES	—	—

	Wood	Other
S3 EXTERIOR WALLS	☐	☐

	Attached	Detached
S4 STRUCTURE TYPE	☐	☐

	Toilets	Baths
S5 NUMBER OF TOILETS AND BATHS	—	—

	Yes	No
S6 LIVING UNIT IN BASEMENT	☐	☐

	Street	Rear Yard	Alley
S7 MAIN ACCESS	☐	☐	☐

	Public	Private	None
S8 WATER SUPPLY	☐	☐	☐
S9 SEWER CONNECTION	☐	☐	☐

SUPPLEMENTARY APPRAISAL

	Yes	No
S8a WATER SUPPLY Nonpublic water supply acceptable to Health Dept.	☐	☐
S9a SEWER CONNECTION Nonpublic sewage disposal acceptable to Health Dept.	☐	☐

S16a DAYLIGHT OBSTRUCTION

Side	This Str.	Adjacent Structure		
	No. of Windows	Height in Stories	Distance in Feet	Horiz. Obstr.
	a	b	c	d
Front				
Left				
Right				
Rear				

(office entries)

Obstruction Factor: Total h/Total e ____

Side	Adj. a	Table	$f \times d$	$e \times g$
	e	f	g	h
Front				
Left				
Right				
Rear				

Total e ____ Total h ____

DHEW-ATLANTA, GA.

S10 STAIRS AND FIRE ESCAPES (for two-story tenements and all structures of three or more stories)

☐ Item Not Applicable

	Front Stairway		Rear Stairway		Outside Fire Escapes	
	None ☐		None ☐		None ☐	
	Yes	No	Yes	No	Yes	No
Free from obstruction	☐	☐	☐	☐	☐	☐
Clear egress at ground level	☐	☐	☐	☐	☐	☐
Fireproof construction throughout					☐	☐
Free from vertical ladders above first story					☐	☐

S11 PUBLIC HALL LIGHTING

☐ No Public Hall

	No	Yes	Ext.
Daytime lighting deficient	☐	☐	☐

	None	Part	All
Halls lacking light fixtures	☐	☐	☐

S12 DETERIORATION INDEX

	Deg. 0	Deg. 1	Deg. 2
Inside Stairs			
Steps deteriorated	☐	☐	☐
Rails deteriorated	☐	☐	☐
Public Hall Walls, Ceilings			
Hole or surface worn	☐	☐	☐
Surface broken or loose	☐	☐	☐
Public Hall or Porch Floors			
Hole or surface worn	☐	☐	☐
Surface broken or loose	☐	☐	☐

S13 INFESTATION INDEX

	Not Evd.	Re-ptd.	Ob-svd.
Rats in structure or yard	☐	☐	☐
Other vermin	☐	☐	☐

S14 SANITARY INDEX

	No	Yes	Ext.
Refuse containers defective	☐	☐	☐
Garbage accumulated	☐	☐	☐
Other refuse accumulated	☐	☐	☐

S12 DETERIORATION INDEX

	Deg. 0	Deg. 1	Deg. 2
Outside Stairs			
Steps deteriorated	☐	☐	☐
Rails deteriorated	☐	☐	☐
Outside Walls			
Hole or surface worn	☐	☐	☐
Surface broken or loose	☐	☐	☐

S15 BASEMENT CONDITION INDEX

☐ No Basement

	Not Evd.	Re-ptd.	Ob-svd.
Leakage or backflooding	☐	☐	☐
Stairs hazardous	☐	☐	☐
Combustibles accumulated	☐	☐	☐

S16 DAYLIGHT OBSTRUCTION

	No	Yes	Ext.
Condition warranting supplementary appraisal	☐	☐	☐

REMARKS (refer to items by number)

Inspected by ____ Date ____

Time begun ____ Time finished ____ Total time ____

Office check ____ Field check ____

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Fig. 2

Note for Recall _____

Serial No. U_____

Sheet_____ of_____

ROOMING UNIT SCHEDULE

Inspection No. _____ Address _____ District No. _____ Block No. _____ Structure No. _____

Floor _____ Part of Floor _____ Unit No. _____ Vacant ☐

R1 SPECIAL FACILITIES

	Yes	No
Cross ventilation: all rooms	☐	☐
Local item R1a	☐	☐
Local item R1b	☐	☐
Local item R1c	☐	☐

R2 TOILETS

	Ins. Unit	Outs. Unit	Outs. Struc.	None Avail.
Location, no.	☐	☐	☐	☐
	Flush W.C.	Std. Privy	Other Privy	Flush Hopper
Type, no.	☐	☐	☐	☐

Sharing: no. occupants per toilet ___

Condition Index	Yes	No
All toilets in working order	☐	☐
All with artificial light	☐	☐
All with window or duct	☐	☐

R3 BATHS

	Ins. Unit	Outs. Unit	Outs. Struc.	None Avail.
Location, no.	☐	☐	☐	☐
	Hot Tub	Hot Shower	Cold Tub	Cold Shower
Type, no.	☐	☐	☐	☐

Sharing: no. occupants per bath ___

R4 WATER SUPPLY

Ins. Hot	Ins. Cold	Outs. Unit	Outs. Struc.
☐	☐	☐	☐

R5 WASH BASINS

	Yes	No
All basins with hot water	☐	☐
Basin for each 8 occupants	☐	☐

R6 DUAL EGRESS: ALL ROOMS

Yes	No
☐	☐

R7 ELECTRIC LIGHTING

All	Part	None
☐	☐	☐

R8 CENTRAL HEATING

All	Part	None
☐	☐	☐

REMARKS (refer to items by number)

_____

_____

_____

_____

R9 ROOM FACILITIES — TOTAL NUMBER OF ROOMS IN UNIT _____

	1	2	3	4	5	6	7	8	9	10	11	12	Total ABOVE R13
Floor or room no. (no.)													
No. occupants (persons)													
Bed capacity (persons)													
Lacking inst. heater (x)													
Lacking window (x)													
Lacking closet (x)													
Dimensions (ft.)	—	—	—	—	—	—	—	—	—	—	—	—	
Rent: per week ($)													AVG. IN R16
Rent: per month ($)													
Area: sleeping (ft.)													OPP. DIMENS.
Area: nonsleeping (ft.)													
Area: substandard (x)													

R10 DETERIORATION INDEX

	Deg. 0	Deg. 1	Deg. 2
Walls and Ceilings			
Hole, surface worn	☐	☐	☐
Surface broken, loose	☐	☐	☐
Floors			
Hole, surface worn	☐	☐	☐
Surface broken, loose	☐	☐	☐
Windows			
Broken or defective	☐	☐	☐

R11 INFESTATION INDEX

	Not Evd.	Re-ptd.	Ob-svd.
Rats in unit	☐	☐	☐
Other vermin	☐	☐	☐

R12 SANITARY INDEX

	Not Evd.	Re-ptd.	Ob-svd.
Plumbing leakage	☐	☐	☐
Plumbing obstruction	☐	☐	☐
Water pressure low	☐	☐	☐
Walls or floors damp	☐	☐	☐
Heater hazardous	☐	☐	☐
Wiring hazardous	☐	☐	☐

R13 OCCUPANTS

Number of roomers: total _____

R14 RACE OF OCCUPANTS

White	Nonwht.
☐	☐

R15 TENURE OF OPERATOR

Tenant	Owner	Bldg. Empl.
☐	☐	☐

R16 AVERAGE ROOM RENT $_____

Mo.	Wk.
☐	☐

Rent includes meals ☐ Yes ☐ No

SUPPLEMENTARY REMARKS

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Inspected by_____ Date_____

Office check_____ Field check_____

Form DS-3: Copyright 1944, Committee on the Hygiene of Housing, American Public Health Association

FSA-ATLANTA, GA

Fig. 3

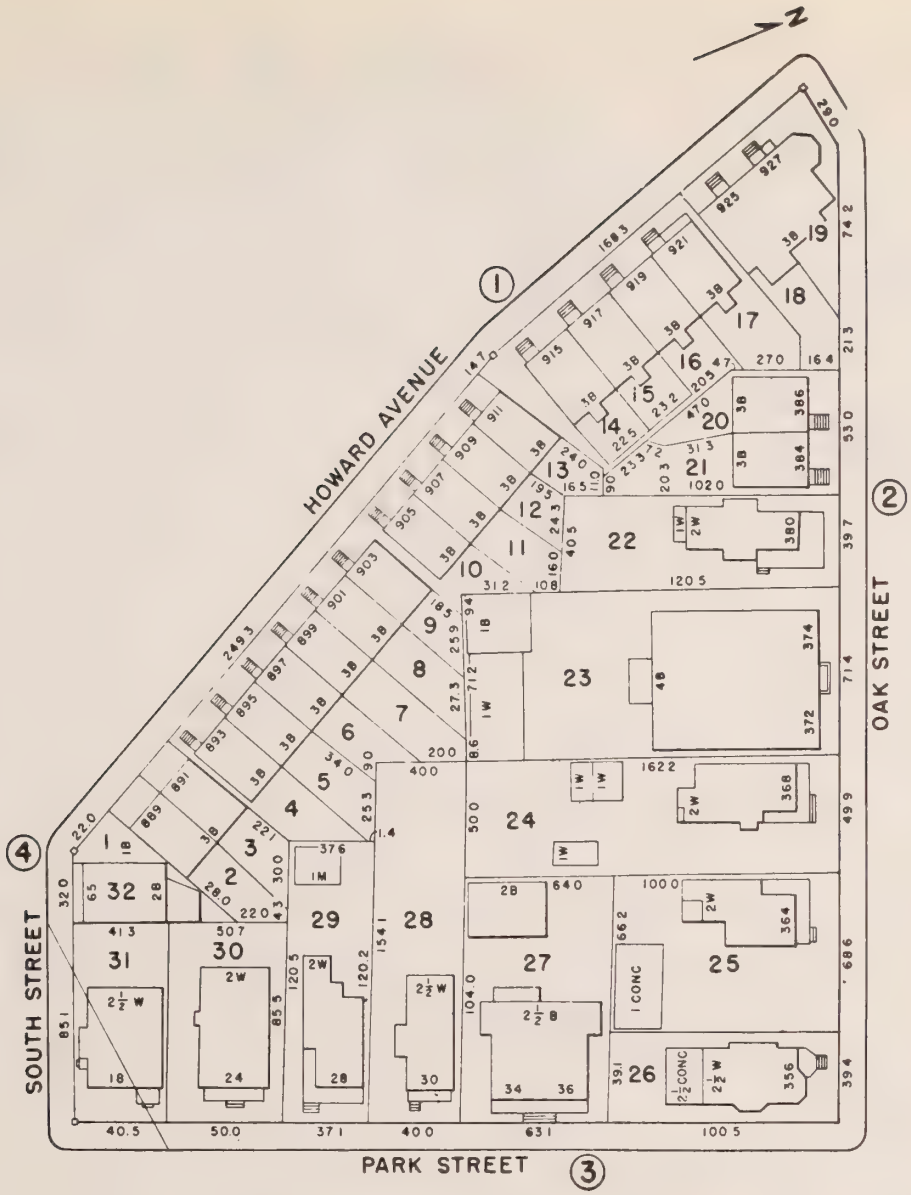

Fig. 4. Specimen Block Map

in non-residential use, such as parks or blocks occupied entirely by business, industry or institutions. Wholly non-residential blocks are not scored, and neither a Block Map nor Land Use Schedule (Figure 5) need be supplied for them. If there be any question, however, as to non-residential status both a Block Map and Land Use Schedule should be issued for the block in question, for checking in the field.

The Land Use Schedule is prepared for each block containing any dwelling structure or concerning whose residential status there is any doubt. For a block, found upon inspection to be wholly non-residential, the enumerator will write "non-residential" boldly across the face of the Schedule and return it without further entries. The Land Use Schedule is completed in the office from the collected field data on it and the Block Maps.

Information from Block Maps and Land Use Schedules is brought together on three Block Schedules, (Figs. 6, 7, and 8) which summarize the data in form for scoring the appraisal items by block and frontage. Block Schedules are prepared for residential block in the survey area. Each item in these Schedules has a maximum penalty score as indicated on Chart 1 which is the list of environmental appraisal items on which the environmental survey is based; for example, the maximum penalty score for "Coverage by Structures" is 24, for "Residential Building Density" is 20, for "Population Density" is 10, for "Frontage Daylight Obstruction" is 16, and for the whole item "Land Crowding" it is the sum of all 4 sub-items or 70 points, etc. There are

LAND USE SCHEDULE ENVIRONMENTAL SURVEY CITY _____

FORM E-1: 1945, COMMITTEE ON THE HYGIENE OF HOUSING AMERICAN PUBLIC HEALTH ASSOCIATION

(A)
ENUMERATED BY _____
DATE _____
CHECKED BY _____
DATE _____

(B)
1) PARCELS (NO.) _____
2) PREMISES (NO.) _____
3) RESIDENTIAL PREMISES (NO.) _____
4) MAJOR STRUCTURES (NO.) _____

(C)
1) NET BLOCK AREA (SQ. FT) _____
2) AREA OF MAJOR STRUCTURES (SQ. FT) _____
3) AREA OF MINOR STRUCTURES (SQ. FT.) _____

(D) BLOCK BOUNDED BY (STREET OR OTHER BOUNDARY):
1 _____ FRONTAGE LENGTH (FT.) _____
2 _____ FRONTAGE LENGTH (FT.) _____
3 _____ FRONTAGE LENGTH (FT.) _____
4 _____ FRONTAGE LENGTH (FT.) _____
5 _____ FRONTAGE LENGTH (FT.) _____

(E)
DISTRICT _____
BLOCK _____
SHEET ____ OF ____ SHEETS

LINE NUMBER	PREMISES: FIELD ENTRIES: NAME OF STREET OR OTHER BOUNDARY	PREMISE NO	TYPE OF LAND USE: RESIDENTIAL (CHECK)	TYPE OF LAND USE: NONRESIDENTIAL (DESCRIBE BY TYPES)	PREMISES: OFFICE ENTRIES: LAND USE CATEGORY (CODE)	AREA OF PREMISES (SQ. FT.)	FRONTAGE LENGTH ON BLOCK BOUNDARIES (FT.)	MAJOR STRUCTURES: FIELD ENTRIES: STREET NO	MAJOR STRUCTURE NO	TYPE: RESIDENTIAL (CODE)	TYPE: MIXED RESIDENTIAL AND BUSINESS (CODE)	TYPE: NONRESIDENTIAL (CHECK)	AVAILABILITY STATUS (CODE)	NUMBER OF STORIES	NO. OF FLOORS OCCUPIED BY BUSINESS OR NOURES	MAJOR STRUCTURES: OFFICE ENTRIES: GROUND AREA OF STRUCTURE (SQ. FT.)	RESIDENTIAL FLOOR AREA (SQ. FT.)	SET BACK OF STRUCTURE (FT.)	MINOR STRUCTURES: FIELD ENTRIES: MINOR STRUCTURE NO	TYPE AND USE (DESCRIBE)	MINOR STRUCTURES: OFF. ENT.: GROUND AREA (SQ. FT.)
	COLUMN: 1	2	3	4	5	6	7	8 -	9	10	11	12	13	14	15	16	17	18	19	20	21
1																					
2																					
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					
11																					
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17																					
18																					
19																					
20																					
21																					
22																					
23																					
24																					
25																					
26																					

CODE

FIELD

COL. 10 RESIDENTIAL

1-FAMILY DETACHED	1-D
1-FAMILY OTHER	1-O
2-FAMILY	2
3-FAMILY	3
4-6 FAMILY	4
7-OR MORE FAMILY	7
HOTEL OR ROOMING HOUSE	H
OTHER RESIDENTIAL	OR

COL. 11 MIXED RESIDENTIAL AND BUSINESS

1 OR 2-FAM. WITH BUS.	B1
3-FAMILY WITH BUS	B3
4-6 FAMILY WITH BUS.	B4
7 OR MORE FAMILY WITH BUSINESS	B7
HOTELS, ETC. WITH BUS.	BH

COL. 13 AVAILABILITY STATUS

OCCUPIED	O
VACANT (AVAILABLE)	A
VACANT (UNAVAILABLE)	V
UNDER CONSTRUCTION	UC

OFFICE

COL. 5 LAND USE CATEGORY

RESIDENTIAL	R
MIXED RES. AND BUS.	M
INDUSTRIAL	I
COMMERCIAL	C
PUBLIC OR SEMI-PUB.	P
UNUSED LAND	U
NOT KNOWN	N

Fig. 5 Land Use Schedule

BLOCK SCHEDULE A - ENVIRONMENTAL SURVEY - CITY_____

IDENTIFICATION AND GENERAL BLOCK DATA

	BLOCK BOUNDED BY: NAME OF STREET OR OTHER BOUNDARY:	PAVEMENT WIDTH: CENTER LINE TO CURB:	STREET WIDTH: CENTER LINE TO PROPERTY LINE:	BLOCK FRONTAGE LENGTH:
1		FT.	FT.	FT.
2		FT.	FT.	FT.
3		FT.	FT.	FT.
4		FT.	FT.	FT.

DISTRICT . . . . . _____
BLOCK . . . . . _____
. . . . . _____
. . . . . _____
DWLG. SERIAL NO._____ TO NO._____
ENTRIES BY_____ DATE_____

(a) TOTAL NUMBER OF PARCELS . . . . . _____
(b) TOTAL NUMBER OF PREMISES . . . . . _____
(c) TOTAL NUMBER OF RESIDENTIAL (INCL. MIXED) PREMISES. . _____
(d) TOTAL NUMBER OF MAJOR STRUCTURES. . . . . _____
(e) TOTAL NUMBER OF STRUCTURES CONTAINING DWELLINGS . . . _____
(f) TOTAL NUMBER OF LIVING UNITS. . . . . _____

(g) DIMENSIONS OF BLOCK: LENGTH_____FT. WIDTH_____FT.
(h) NET BLOCK AREA_____SQ. FT. _____ACRES
(i) GROSS BLOCK AREA_____SQ. FT. _____ACRES
(j) TOTAL NUMBER OF RESIDENTS . . . . . _____
(k) AVERAGE NUMBER OF LIVING UNITS PER RESIDENTIAL PREMISE. . . . . _____

A. LAND CROWDING

1. COVERAGE BY STRUCTURES

(1) a) COVERAGE BY MAJOR STRUCTURES:

		GROUND AREA	TOTAL FLOOR AREA
(2)	1 STORY STRUCTURES	_____SQ. FT.	_____SQ. FT.
(3)	2 STORY STRUCTURES	_____SQ. FT.	_____SQ. FT.
(4)	3 STORY STRUCTURES	_____SQ. FT.	_____SQ. FT.
(5)	4 STORY STRUCTURES	_____SQ. FT.	_____SQ. FT.
(6)	___ STORY STRUCTURES	_____SQ. FT.	_____SQ. FT.
(7)	___ STORY STRUCTURES	_____SQ. FT.	_____SQ. FT.
(8)	___ STORY STRUCTURES	_____SQ. FT.	_____SQ. FT.
(9)	___ STORY STRUCTURES	_____SQ. FT.	_____SQ. FT.
(10)	TOTAL FOR ALL STRS.	_____SQ. FT.	_____SQ. FT.

(11) AVERAGE STRUCTURE HEIGHT . . . . . _____
(12) PERCENT OF GROSS BLOCK AREA COVERED. . . _____% PENALTY SCORE_____

(13) b) COVERAGE BY MINOR STRUCTURES:
(14) TOTAL AREA COVERED_____SQ. FT.
(15) PERCENT OF NET BLOCK AREA . . . . . _____% PENALTY SCORE_____

COMBINED PENALTY_____

2. RESIDENTIAL BUILDING DENSITY.

(1) AREA OF RESIDENTIAL PREMISES . . . . . _____SQ. FT.
(2) AREA OF MIXED (RESIDENTIAL AND BUSINESS) PREMISES._____SQ. FT.
(3) TOTAL AREA OF RESIDENTIAL AND MIXED PREMISES . . . _____SQ. FT.
(4) TOTAL RESIDENTIAL FLOOR AREA . . . . . _____SQ. FT.

(5) a) RATIO OF RESIDENTIAL FLOOR AREA TO AREA OF RESIDENTIAL AND MIXED PREMISES . . . . . _____

PENALTY SCORE_____

(6) b) AREA OF MIXED PREMISES AS PERCENT OF RESIDENTIAL AND MIXED PREMISES AREA . . . . . _____%

PENALTY SCORE_____

COMBINED PENALTY_____

3. POPULATION DENSITY

(1) TOTAL RESIDENTIAL FLOOR AREA_____SQ. FT.
(2) NUMBER OF RESIDENTS . . . . . _____PERSONS
(3) RESIDENTIAL FLOOR AREA PER PERSON_____SQ. FT. PENALTY SCORE_____

4. RESIDENTIAL YARD AREAS

(1) LIVING UNITS PER RESIDENTIAL PREMISE (AVERAGE)
1.0 - 1.9 ☐ 2.0 - 3.9 ☐ 4.0 - 6.9 ☐ 7 AND OVER ☐
(2) TOTAL RESIDENTIAL PREMISES (NUMBER) . . . . . _____
(3) RESIDENTIAL PREMISES LACKING MINIMUM UNBUILT YARD AREA (NUMBER) . . . _____
(4) NUMBER OF RESIDENTIAL PREMISES LACKING MINIMUM YARD AREA AS PERCENT OF TOTAL RESIDENTIAL PREMISES. . . . . _____%

PENALTY SCORE_____

B. NONRESIDENTIAL LAND USES

5. AREAL INCIDENCE OF NONRESIDENTIAL LAND USES

	AREA IN FOLLOWING USES:	NET AREA	% OF NET BLOCK AREA
(1)	RESIDENTIAL	_____SQ. FT.	_____%
(2)	MIXED (RESIDENTIAL AND BUSINESS	_____SQ. FT.	_____%
(3)	INDUSTRIAL.	_____SQ. FT.	_____%
(4)	COMMERCIAL.	_____SQ. FT.	_____%
(5)	PUBLIC OR SEMI-PUBLIC	_____SQ. FT.	_____%
(6)	UNUSED LAND	_____SQ. FT.	_____%

(7) PERCENT OF NET BLOCK AREA IN INDUSTRIAL, COMMERCIAL, AND MIXED USE. . . . . _____%

PENALTY SCORE_____

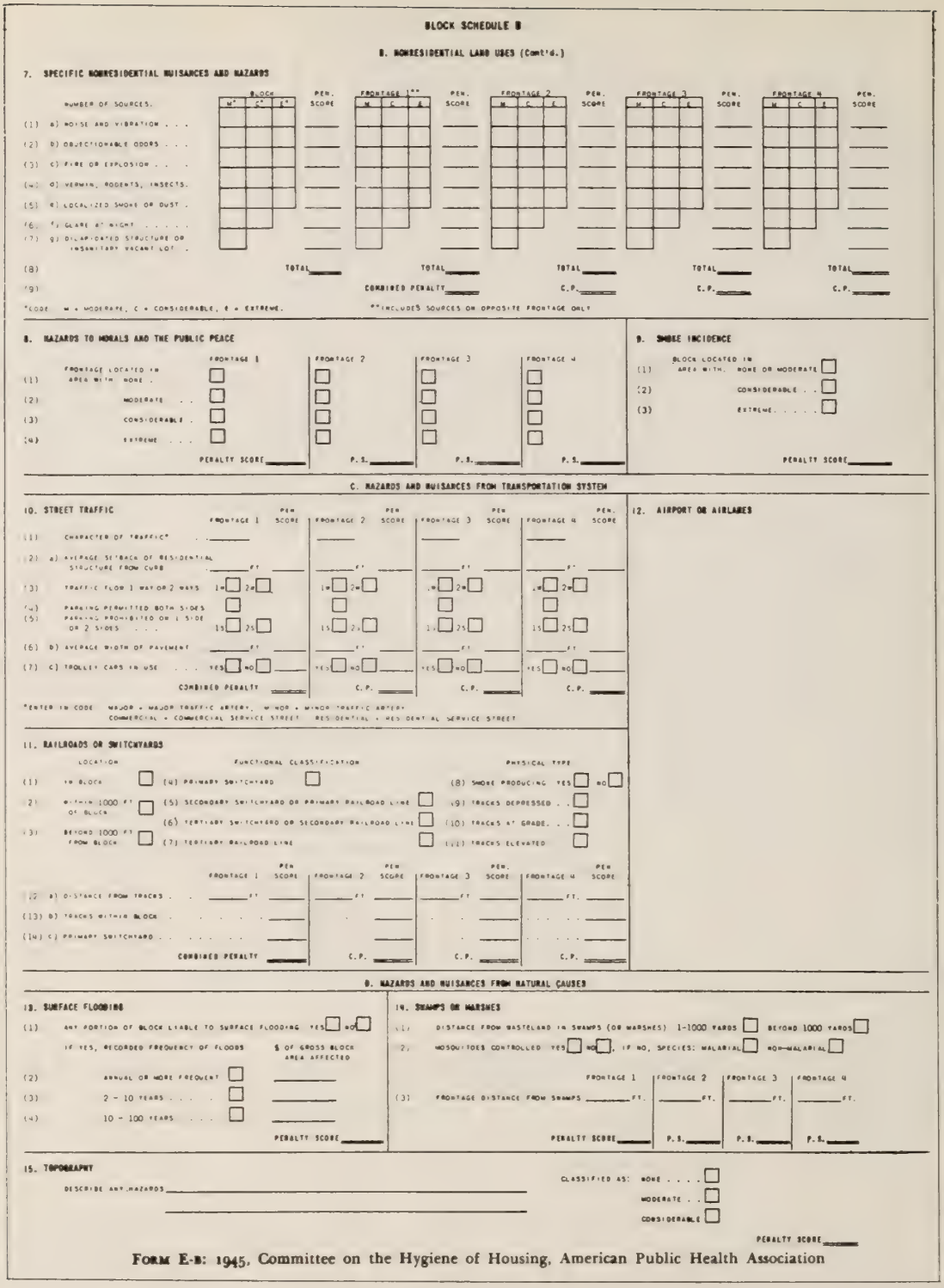
6. LINEAR INCIDENCE OF NONRESIDENTIAL LAND USES

		FRONTAGE 1	FRONTAGE 2	FRONTAGE 3	FRONTAGE 4
(1)	LENGTHS: BLOCK FRONTAGE. . .	_____FT.	_____FT.	_____FT.	_____FT.
(2)	OPPOSITE FRONTAGE .	_____FT.	_____FT.	_____FT.	_____FT.
(3)	TOTAL	_____FT.	_____FT.	_____FT.	_____FT.
(4)	LENGTHS IN IND., COMML., AND MIXED USES: BLOCK FRONTAGE .	_____FT.	_____FT.	_____FT.	_____FT.
(5)	OPPOSITE FRONTAGE .	_____FT.	_____FT.	_____FT.	_____FT.
(6)	TOTAL	_____FT.	_____FT.	_____FT.	_____FT.
(7)	PERCENT OF TOTAL FRONTAGES IN IND., COMML., AND MIXED USE .	_____%	_____%	_____%	_____%
		PENALTY SCORE_____	P. S._____	P. S._____	P. S._____

FORM E-2A: 1945, Committee on the Hygiene of Housing, American Public Health Association

Fig. 6 Block Schedule A

DHEW-ATLANTA, GA.



BLOCK SCHEDULE B

B. NONRESIDENTIAL LAND USES (Cont'd.)

7. SPECIFIC NONRESIDENTIAL NUISANCES AND HAZARDS

Number of Sources.	Block M*	Block C*	Block E*	Pen. Score	Frontage 1** M	Frontage 1** C	Frontage 1** E	Pen. Score	Frontage 2 M	Frontage 2 C	Frontage 2 E	Pen. Score	Frontage 3 M	Frontage 3 C	Frontage 3 E	Pen. Score	Frontage 4 M	Frontage 4 C	Frontage 4 E	Pen. Score
(1) a) Noise and vibration																				
(2) b) Objectionable odors																				
(3) c) Fire or explosion																				
(4) d) Vermin, rodents, insects																				
(5) e) Localized smoke or dust																				
(6) f) Glare at night																				
(7) g) Dilapidated structure or insanitary vacant lot																				
(8)				Total				Total				Total				Total				Total
(9)								Combined Penalty				C.P.				C.P.				C.P.

*Code: M = Moderate, C = Considerable, E = Extreme.

**Includes sources on opposite frontage only.

8. HAZARDS TO MORALS AND THE PUBLIC PEACE

Frontage Located in Area with:	Frontage 1	Frontage 2	Frontage 3	Frontage 4
(1) None	☐	☐	☐	☐
(2) Moderate	☐	☐	☐	☐
(3) Considerable	☐	☐	☐	☐
(4) Extreme	☐	☐	☐	☐
	Penalty Score	P.S.	P.S.	P.S.

9. SMOKE INCIDENCE

Block Located in Area with:

(1) None or moderate ☐

(2) Considerable ☐

(3) Extreme ☐

Penalty Score

C. HAZARDS AND NUISANCES FROM TRANSPORTATION SYSTEM

10. STREET TRAFFIC

	Frontage 1	Pen. Score	Frontage 2	Pen. Score	Frontage 3	Pen. Score	Frontage 4	Pen. Score
(1) Character of traffic*								
(2) a) Average setback of residential structure from curb	____ ft		____ ft		____ ft		____ ft	
(3) Traffic flow 1 way or 2 ways	1☐ 2☐		1☐ 2☐		1☐ 2☐		1☐ 2☐	
(4) Parking permitted both sides	☐		☐		☐		☐	
(5) Parking prohibited on 1 side or 2 sides	1S☐ 2S☐		1S☐ 2S☐		1S☐ 2S☐		1S☐ 2S☐	
(6) b) Average width of pavement	____ ft		____ ft		____ ft		____ ft	
(7) c) Trolley cars in use	Yes☐ No☐		Yes☐ No☐		Yes☐ No☐		Yes☐ No☐	
	Combined Penalty		C.P.		C.P.		C.P.	

*Enter in code: Major = Major traffic artery, Minor = Minor traffic artery, Commercial = Commercial service street, Residential = Residential service street.

12. AIRPORT OR AIRLANES

11. RAILROADS OR SWITCHYARDS

Location	Functional Classification	Physical Type
(1) In block ☐	(4) Primary switchyard ☐	(8) Smoke producing Yes☐ No☐
(2) Within 1000 ft of block ☐	(5) Secondary switchyard or primary railroad line ☐	(9) Tracks depressed ☐
	(6) Tertiary switchyard or secondary railroad line ☐	(10) Tracks at grade ☐
(3) Beyond 1000 ft from block ☐	(7) Tertiary railroad line ☐	(11) Tracks elevated ☐

	Frontage 1	Pen. Score	Frontage 2	Pen. Score	Frontage 3	Pen. Score	Frontage 4	Pen. Score
(12) a) Distance from tracks	____ ft		____ ft		____ ft		____ ft	
(13) b) Tracks within block								
(14) c) Primary switchyard								
	Combined Penalty		C.P.		C.P.		C.P.	

D. HAZARDS AND NUISANCES FROM NATURAL CAUSES

13. SURFACE FLOODING

(1) Any portion of block liable to surface flooding: Yes☐ No☐

If yes, recorded frequency of floods	$ of gross block area affected
(2) Annual or more frequent ☐	
(3) 2 - 10 years ☐	
(4) 10 - 100 years ☐	

Penalty Score

14. SWAMPS OR MARSHES

(1) Distance from wasteland in swamps (or marshes): 1-1000 yards ☐ Beyond 1000 yards ☐

(2) Mosquitoes controlled: Yes☐ No☐; if no, species: Malarial☐ Non-malarial☐

	Frontage 1	Frontage 2	Frontage 3	Frontage 4
(3) Frontage distance from swamps	____ ft.	____ ft.	____ ft.	____ ft.
	Penalty Score	P.S.	P.S.	P.S.

15. TOPOGRAPHY

Describe any hazards: _____

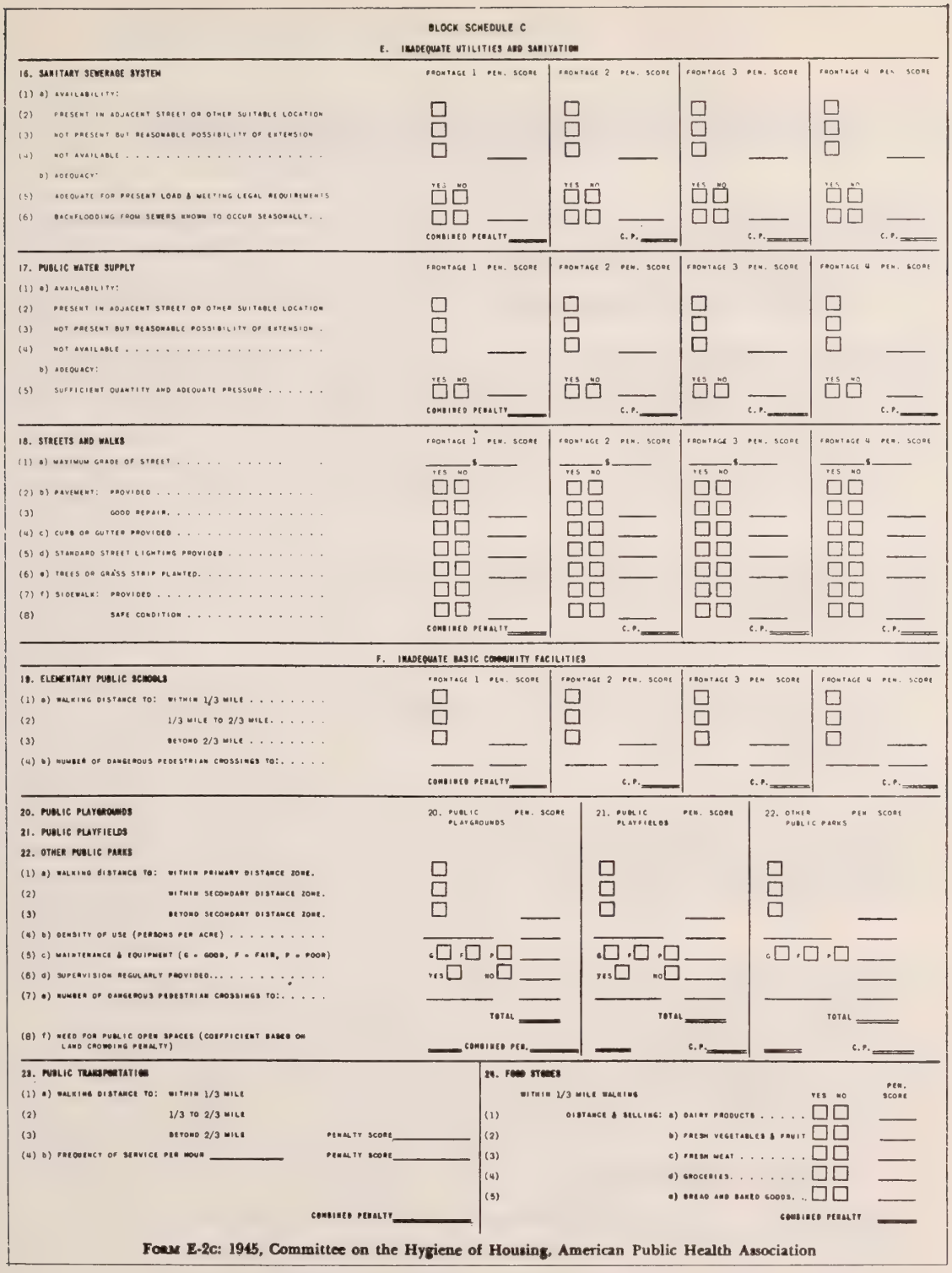
Classified as: None ☐ Moderate ☐ Considerable ☐

Penalty Score

FORM E-B: 1945, Committee on the Hygiene of Housing, American Public Health Association

Fig. 7 Block Schedule B

DHEW-ATLANTA, GA.



BLOCK SCHEDULE C

E. INADEQUATE UTILITIES AND SANITATION

16. SANITARY SEWERAGE SYSTEM — FRONTAGE 1 PEN. SCORE | FRONTAGE 2 PEN. SCORE | FRONTAGE 3 PEN. SCORE | FRONTAGE 4 PEN. SCORE

(1) a) AVAILABILITY:
(2) PRESENT IN ADJACENT STREET OR OTHER SUITABLE LOCATION
(3) NOT PRESENT BUT REASONABLE POSSIBILITY OF EXTENSION
(4) NOT AVAILABLE
b) ADEQUACY:
(5) ADEQUATE FOR PRESENT LOAD & MEETING LEGAL REQUIREMENTS — YES NO
(6) BACKFLOODING FROM SEWERS KNOWN TO OCCUR SEASONALLY — YES NO
COMBINED PENALTY | C. P. | C. P. | C. P.

17. PUBLIC WATER SUPPLY — FRONTAGE 1 PEN. SCORE | FRONTAGE 2 PEN. SCORE | FRONTAGE 3 PEN. SCORE | FRONTAGE 4 PEN. SCORE

(1) a) AVAILABILITY:
(2) PRESENT IN ADJACENT STREET OR OTHER SUITABLE LOCATION
(3) NOT PRESENT BUT REASONABLE POSSIBILITY OF EXTENSION
(4) NOT AVAILABLE
b) ADEQUACY:
(5) SUFFICIENT QUANTITY AND ADEQUATE PRESSURE — YES NO
COMBINED PENALTY | C. P. | C. P. | C. P.

18. STREETS AND WALKS — FRONTAGE 1 PEN. SCORE | FRONTAGE 2 PEN. SCORE | FRONTAGE 3 PEN. SCORE | FRONTAGE 4 PEN. SCORE

(1) a) MAXIMUM GRADE OF STREET — %
(2) b) PAVEMENT: PROVIDED — YES NO
(3) GOOD REPAIR
(4) c) CURB OR GUTTER PROVIDED
(5) d) STANDARD STREET LIGHTING PROVIDED
(6) e) TREES OR GRASS STRIP PLANTED
(7) f) SIDEWALK: PROVIDED
(8) SAFE CONDITION
COMBINED PENALTY | C. P. | C. P. | C. P.

F. INADEQUATE BASIC COMMUNITY FACILITIES

19. ELEMENTARY PUBLIC SCHOOLS — FRONTAGE 1 PEN. SCORE | FRONTAGE 2 PEN. SCORE | FRONTAGE 3 PEN. SCORE | FRONTAGE 4 PEN. SCORE

(1) a) WALKING DISTANCE TO: WITHIN 1/3 MILE
(2) 1/3 MILE TO 2/3 MILE
(3) BEYOND 2/3 MILE
(4) b) NUMBER OF DANGEROUS PEDESTRIAN CROSSINGS TO:
COMBINED PENALTY | C. P. | C. P. | C. P.

20. PUBLIC PLAYGROUNDS
21. PUBLIC PLAYFIELDS
22. OTHER PUBLIC PARKS

	20. PUBLIC PLAYGROUNDS PEN. SCORE	21. PUBLIC PLAYFIELDS PEN. SCORE	22. OTHER PUBLIC PARKS PEN. SCORE
(1) a) WALKING DISTANCE TO: WITHIN PRIMARY DISTANCE ZONE.			
(2) WITHIN SECONDARY DISTANCE ZONE.			
(3) BEYOND SECONDARY DISTANCE ZONE.			
(4) b) DENSITY OF USE (PERSONS PER ACRE)			
(5) c) MAINTENANCE & EQUIPMENT (G = GOOD, F = FAIR, P = POOR)	G F P	G F P	G F P
(6) d) SUPERVISION REGULARLY PROVIDED	YES NO	YES NO	
(7) e) NUMBER OF DANGEROUS PEDESTRIAN CROSSINGS TO:			
	TOTAL	TOTAL	TOTAL
(8) f) NEED FOR PUBLIC OPEN SPACES (COEFFICIENT BASED ON LAND CROWDING PENALTY)	COMBINED PEN.	C. P.	C. P.

23. PUBLIC TRANSPORTATION

(1) a) WALKING DISTANCE TO: WITHIN 1/3 MILE
(2) 1/3 TO 2/3 MILE
(3) BEYOND 2/3 MILE — PENALTY SCORE
(4) b) FREQUENCY OF SERVICE PER HOUR — PENALTY SCORE
COMBINED PENALTY

24. FOOD STORES

WITHIN 1/3 MILE WALKING DISTANCE & SELLING: — YES NO — PEN. SCORE

(1) a) DAIRY PRODUCTS
(2) b) FRESH VEGETABLES & FRUIT
(3) c) FRESH MEAT
(4) d) GROCERIES
(5) e) BREAD AND BAKED GOODS
COMBINED PENALTY

FORM E-2c: 1945, Committee on the Hygiene of Housing, American Public Health Association

DHEW-ATLANTA, GA.

Fig. 8 Block Schedule C

Chart 1

ENVIRONMENTAL SURVEY: APPRAISAL ITEMS AND MAXIMUM STANDARD PENALTY SCORES

Item	Maximum Score	
A. Land Crowding		
1. Coverage by Structures	24	
2. Residential Building Density	20	
3. Population Density	10	
4. Frontage Daylight Obstruction[1]	16	70
B. Nonresidential Land Uses		
5. Areal Incidence of Nonresidential Land Use	13	
6. Linear Incidence of Nonresidential Land Use	13	
7. Hazards and Nuisances from Industrial or Commercial Sources	30	
8. Hazards to Morals and the Public Peace	10	
9. Smoke Incidence	6	72
C. Hazards and Nuisances from Transportation System		
10. Street Traffic	20	
11. Railroads and Switchyards	24	
12. Airports[1]	20	64
D. Hazards and Nuisances from Natural Causes		
13. Surface Flooding	20	
14. Swamps or Marshes	24	
15. Topography	16	60
E. Inadequate Utilities and Sanitation		
16. Sanitary Sewerage System	24	
17. Public Water Supply	20	
18. Streets and Walks	10	54
F. Inadequate Basic Community Facilities		
19. Elementary Public Schools	10	
20. Public Playgrounds	8	
21. Public Playfields	4	
22. Other Public Parks	8	
23. Public Transportation	12	
24. Food Stores[1]	6	48
MAXIMUM ENVIRONMENT TOTAL		368

[1]Provisional item, not tested

also available for use two Abridged Block Schedules for abridged survey procedures. They should be used only in cases where the survey director has already become familiar with the philosophy and general operation of the complete procedures.

Nuisance Schedules (Fig. 9) are prepared by examining column 4 of the Land Use Schedule for non-residential premises if a type likely to cause nuisance be eligible for scoring. Chart 2 gives classification of the potential nuisance industries.

Forms 1, 2, 3, 4, 5, 6, 7, 8 and 9 are not scoring cards. They merely enumerate information concerning the conditions of the dwelling units, structure, premises, and environment. These forms are filled out in the field during survey inspection. The environmental schedule may require office sources, such as maps, to complete its execution.

3. The field schedules are brought to the office of the survey director whose office crew examines them and translates the information of these field schedules into scores on the forms shown in Fig. 10, the Unit Appraisal Form. Each item on the Unit Appraisal Form schedule has a maximum penalty score (Chart 3). Coding is done by preparing the Punching Code Sheet (Fig. 11) which is attached to the right edge of the Unit Appraisal Form. The Punching Code Sheet translates the entries in the Unit Appraisal Form into code symbols from which a statistical card, the Unit Punch Card (Fig. 12), is punched.

After each dwelling quality is translated into scores, an expeditious system of tabulation, analysis, and interpretation is carried on by the office crew. Various forms and tables are used, mechanical tabulation and card punching are utilized, and various statistical devices are employed to correlate the information accumulated by the field workers. In general, the scores of the individual dwellings are consolidated on cumulative forms to indicate the quality of housing for each area surveyed. Then the area analyses are further consolidated on cumulative forms to indicate the quality of housing of the districts which are composed of the various areas.

The Block Appraisal Form (Fig. 13) is a sheet on which the penalty scores for all major items of the environmental schedules are summarized in order to permit rapid tabulation and analysis of the findings. This appraisal form is completed by transcription from the three Block Schedules, Figs. 6, 7 and 8. Those blocks which are contiguous and of similar quality are combined to indicate homogeneous areas, and such areas are then graphically transposed to a blank chart (Fig. 14), which when translated in graphical form resembles Fig. 15 and indicates the "Range of Environment Total Scores by Appraisal Area".

Fig. 15 illustrates the chart used to show the quality of dwelling conditions in the areas of a particular district, and how it is possible to compare the over-all conditions of one area to another. It shows comparative total score ranges for districts. It measures the range of the problem. Grouping by quality grade is indicated by the heavy vertical bars for each area. It is prepared by tabulating the scores of all block frontage in each appraisal area and computing the median and quartile values. The median value is the midpoint which divides a particular group into better and worse or higher and lower conditions or positions. The medians are shown by the heavy crossbars (which intersect the heavy vertical bars) with the numerical values indicated. If, then, the medians for the better and for the worse groups, or for the higher or lower groups be further determined, the secondary median points are called quartiles. Quartiles therefore divide a whole group into 4 parts. The two ends of each heavy vertical bar indicate the midpoints which divide the range of better scores into halves, and the worse scores into halves. Each heavy vertical bar itself shows the median range between the 4 quartiles and is called the "range-graph." The latter, therefore, indicates the spread of the scores for the middle 50% of frontage, giving a convenient graphic index of good or poor conditions. The particular chart shown in Fig. 15 indicates a wide range of quality for the particular survey, from a 27 point median for the best grade B areas to a 112 point median for the poorest in grade E. Thus, the chart reveals the relative quality of the sample areas at a glance, from the best areas to the poorest. These areas are classified into 5 quality grades, from A to E (grade A is not shown on this particular chart) according to the penalty class and the number of basic deficiencies shown by the median dwelling unit for each area.

NUISANCE SCHEDULE - ENVIRONMENTAL SURVEY - CITY_____

DISTRICT NO._____ BLOCK NO._____ PREMISES NO._____ STRUCTURE NO._____

ADDRESS_____

1. NAME OF FIRM_____

2. NAME AND TITLE OF PERSON INTERVIEWED_____

3. TYPE OF BUSINESS:_____

4. PERIOD OF ACTIVITY: DAY ☐ NIGHT ☐ SPECIAL HOURS:_____

5. MAJOR OPERATIONS_____

6. RAW MATERIALS USED_____

7. FINISHED PRODUCTS_____

8. RECEIVING & SHIPPING: R.R. SIDING ☐ LIGHT TRUCKING ☐ HEAVY TRUCKING ☐ WATER ☐

FRONTAGES AFFECTED_____

NUISANCES EMANATING FROM OR HAZARDS PRESENT IN PREMISES
(N=NONE M=MODERATE C=CONSIDERABLE E=EXTREME)

	N	M	C	E	TYPE, SOURCE, AND FREQUENCY
9. NOISE AND VIBRATION					
10. OBJECTIONABLE ODORS					
11. FIRE OR EXPLOSION HAZARD					
12. VERMIN, RODENTS, OR INSECTS					
13. LOCALIZED SMOKE OR DUST					
14. GLARE AT NIGHT					
15. MAJOR STRUCTURE DILAPIDATED OR VACANT LOT IN INSANITARY COND.					

16. SURVEY CONDUCTED BY: OUTSIDE AND INSIDE INSPECTION ☐ OUTSIDE INSPECTION ONLY ☐

REMARKS_____

ENUMERATOR_____ DATE_____

FORM E 3. 1945, Committee on the Hygiene of Housing, American Public Health Association

Fig. 9. Nuisance Schedule

Types of Nuisance or Hazard	*Symbol*
Objectionable Odors	O
Noise and Vibration	NV
Fire or Explosion	FE
Vermin, Rodents or Insects	V
Localized Smoke or Dust	SD
Glare at Night	G

1. *Metal Products (Extraction, Processing)* (NV, O, SD, G)**

Mining, Foundries, Stamping, Forging; Grinding, Rolling, Testing, etc.

2. *Heavy Machinery (Manufacturing)* (NV, SD, G)

Railroad equipment, Boilers, Tanks, Ships, Airplanes; Machinery, Automobiles, Tractors, Electric equipment, etc.

3. *Light Machinery (Manufacturing)* (NV, G)

Fire arms, Hardware; Tools, Instruments, etc.

4. *Transportation (Storage, Servicing, Repair)* (NV, O, FE, G)

Railroad yards, repair shops, tracks, Garages, Terminals; Auto body repair shops, Commercial parking lots, etc.

5. *Stone, Clay and Glass Products (Extraction, Processing)* (NV, SD)

Quarrying, cutting, grinding, Brickyards, lime kiln, etc.

6 *Building Construction Establishments (Manufacturing, Storage)* (NV, FE)

Fabrication and assembly plants, Storage yards

7 *Forest Products and Paper (Processing, Manufacturing, Storage)* (NV, FE)

Wood working and furniture, Pulp and paper manufacture, Lumber yards; Storage of paper, waste, etc., Printing, newspapers

8 *Products of Petroleum and Coal (Extraction, Processing, Storage, Servicing)* (NV, O, FE, SD, G)

Coal mining, Oil refineries, Coal gas plants, Processing of petroleum and coal; Storage of oil, gasoline, etc., Gasoline stations, Storage and loading of coal, etc.

9 *Chemical and Related Products (Manufacturing, Processing, Storage)* (O, FE)

Rubber, Matches, Explosives and ammunition, Paints and varnishes; Soap, Tar products, Plastics, cellulose, Fertilizers, glue

10 *Textiles, Leather, and Furs (Processing, Manufacturing, Storage, Repair)* (NV, O, FE)

Textile and woolen mills, Tanneries, Clothing, Furs; Shoe manufacturing, Dyeing, Cleaning, Laundries

11 *Foods (Processing, Manufacturing, Storage, Servicing)* (NV, O, V)

Slaughtering and meat packing, Fish canneries, Flour & grain milling & storage, Bakeries, Candy and confectionery; Beer manufacture, Bottling, Food storage and servicing, Food markets, Stable, animals, etc.

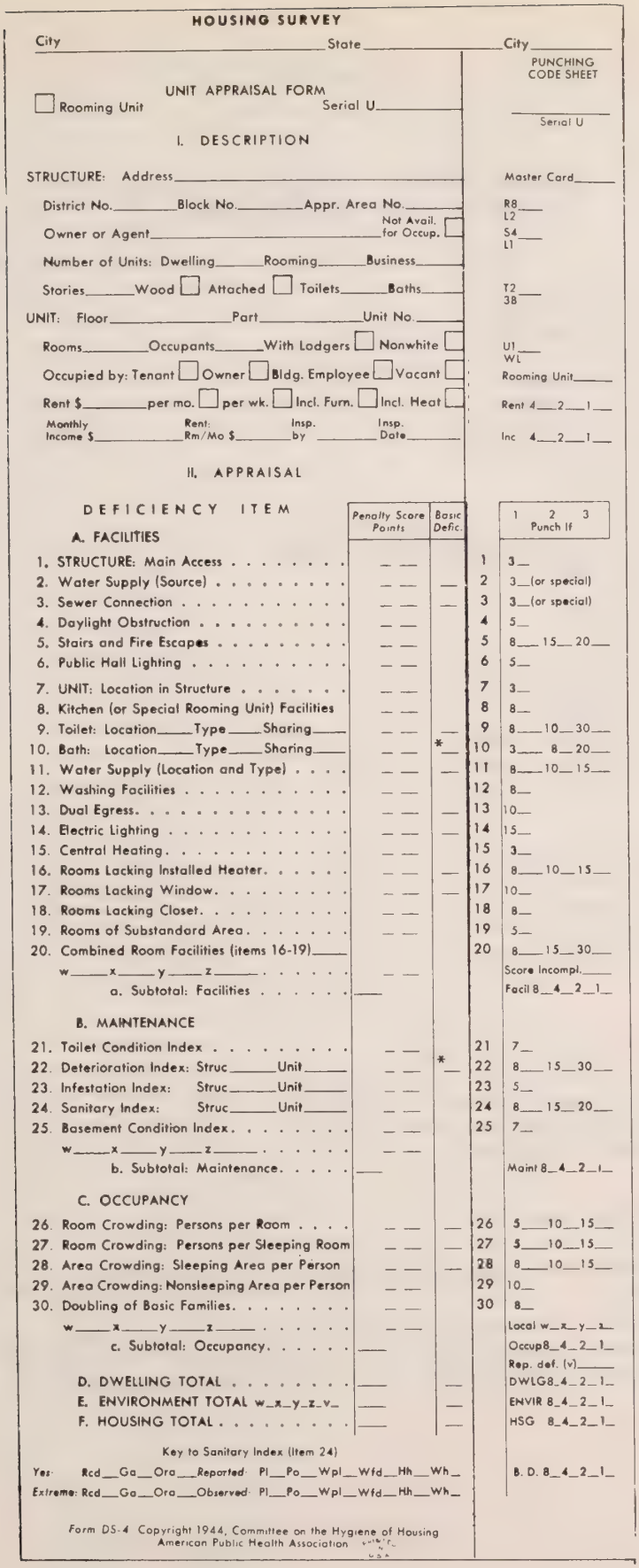
12 *Miscellaneous Other Sources*

Crematoria, Warehouses, Refuse dumps, Junk yards; Storage of miscellaneous waste products, Sewage disposal plants, Dilapidated, abandoned structures, Vacant lots in insanitary condition

* Adapted from a provisional classification of potential nuisance producing industries by the U.S. Public Health Service

** The symbols in parentheses after each heading suggest the most likely nuisances associated with the particular type of enterprise. Other combinations may of course occur

Chart 2. Classification of Potential Nuisance-Producing Industries



HOUSING SURVEY

City _____ State _____ City _____

PUNCHING CODE SHEET

☐ Rooming Unit

UNIT APPRAISAL FORM

Serial U _____

_____ Serial U

I. DESCRIPTION

STRUCTURE: Address _____ Master Card _____

District No. _____ Block No. _____ Appr. Area No. _____ R8 ___ L2

Owner or Agent _____ Not Avail. for Occup. ☐ S4 ___ L1

Number of Units: Dwelling _____ Rooming _____ Business _____

Stories _____ Wood ☐ Attached ☐ Toilets _____ Baths _____ T2 ___ 3B

UNIT: Floor _____ Part _____ Unit No. _____

Rooms _____ Occupants _____ With Lodgers ☐ Nonwhite ☐ U1 ___ WL

Occupied by: Tenant ☐ Owner ☐ Bldg. Employee ☐ Vacant ☐ Rooming Unit _____

Rent $ _____ per mo. ☐ per wk. ☐ Incl. Furn. ☐ Incl. Heat ☐ Rent 4 ___ 2 ___ 1 ___

Monthly Income $ _____ Rent: Rm/Mo $ _____ Insp. by _____ Insp. Date _____ Inc 4 ___ 2 ___ 1 ___

II. APPRAISAL

DEFICIENCY ITEM	Penalty Score Points	Basic Defic.		1 2 3 Punch If
A. FACILITIES				
1. STRUCTURE: Main Access	__ __		1	3__
2. Water Supply (Source)	__ __	__	2	3__(or special)
3. Sewer Connection	__ __	__	3	3__(or special)
4. Daylight Obstruction	__ __		4	5__
5. Stairs and Fire Escapes	__ __		5	8__ 15__ 20__
6. Public Hall Lighting	__ __		6	5__
7. UNIT: Location in Structure	__ __		7	3__
8. Kitchen (or Special Rooming Unit) Facilities	__ __		8	8__
9. Toilet: Location ___ Type ___ Sharing ___	__ __	__	9	8__ 10__ 30__
10. Bath: Location ___ Type ___ Sharing ___	__ __	*__	10	3__ 8__ 20__
11. Water Supply (Location and Type)	__ __	__	11	8__ 10__ 15__
12. Washing Facilities	__ __		12	8__
13. Dual Egress	__ __	__	13	10__
14. Electric Lighting	__ __	__	14	15__
15. Central Heating	__ __		15	3__
16. Rooms Lacking Installed Heater	__ __	__	16	8__ 10__ 15__
17. Rooms Lacking Window	__ __	__	17	10__
18. Rooms Lacking Closet	__ __		18	8__
19. Rooms of Substandard Area	__ __		19	5__
20. Combined Room Facilities (items 16-19) ___			20	8__ 15__ 30__
w ___ x ___ y ___ z ___	__ __			Score Incompl. ___
a. Subtotal: Facilities	___			Facil 8__4__2__1__
B. MAINTENANCE				
21. Toilet Condition Index	__ __		21	7__
22. Deterioration Index: Struc ___ Unit ___	__ __	*__	22	8__ 15__ 30__
23. Infestation Index: Struc ___ Unit ___	__ __		23	5__
24. Sanitary Index: Struc ___ Unit ___	__ __		24	8__ 15__ 20__
25. Basement Condition Index	__ __		25	7__
w ___ x ___ y ___ z ___	__ __			
b. Subtotal: Maintenance	___			Maint 8__4__2__1__
C. OCCUPANCY				
26. Room Crowding: Persons per Room	__ __	__	26	5__ 10__ 15__
27. Room Crowding: Persons per Sleeping Room	__ __	__	27	5__ 10__ 15__
28. Area Crowding: Sleeping Area per Person	__ __	__	28	8__ 10__ 15__
29. Area Crowding: Nonsleeping Area per Person	__ __		29	10__
30. Doubling of Basic Families	__ __		30	8__
w ___ x ___ y ___ z ___	__ __			Local w__x__y__z__
c. Subtotal: Occupancy	___			Occup 8__4__2__1__
				Rep. def. (v) ___
D. DWELLING TOTAL	___	__		DWLG 8__4__2__1__
E. ENVIRONMENT TOTAL w__x__y__z__v__	___	__		ENVIR 8__4__2__1__
F. HOUSING TOTAL	___	__		HSG 8__4__2__1__

Key to Sanitary Index (Item 24)

Yes: Rcd__Ga__Ora__ *Reported* Pl__Po__Wpl__Wfd__Hh__Wh__

Extreme: Rcd__Ga__Ora__ *Observed* Pl__Po__Wpl__Wfd__Hh__Wh__

B. D. 8__4__2__1__

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Fig. 10 Fig. 11

Unit Appraisal Form

Chart 3

DWELLING SURVEY: APPRAISAL ITEMS AND MAXIMUM STANDARD PENALTY SCORES

Item	Maximum Score	
A. Facilities		
1. Structure: Main Access	6	
2. Water Supply (Source for Structure)	25	
3. Sewer Connection	25	
4. Daylight Obstruction	20	
5. Stairs and Fire Escapes	30	
6. Public Hall Lighting	18	
7. Unit: Location in Structure	8	
8. Kitchen Facilities	24	
9. Toilet[1]	45	
10. Bath[1]	20	
11. Water Supply (Location and Type for Unit)	15	
12. Washing Facilities	8	
13. Dual Egress	30	
14. Electric Lighting	15	
15. Central Heating	3	
16. Rooms Lacking Installed Heater	20	
17. Rooms Lacking Window	30	
18. Rooms Lacking Closet	8	
19. Rooms of Substandard Area	10	
20. Combined Room Facilities[2]	-	
		360
B. Maintenance		
21. Toilet Condition Index	12	
22. Deterioration Index[3]	50	
23. Infestation Index[3]	15	
24. Sanitary Index[3]	30	
25. Basement Condition Index	13	
		120
C. Occupancy		
26. Room Crowding: Persons per Room	30	
27. Room Crowding: Persons per Sleeping Room	25	
28. Area Crowding: Sleeping Area per Person	30	
29. Area Crowding: Nonsleeping Area per Person	25	
30. Doubling of Basic Families	10	
		120
Maximum Dwelling Total		600

[1]Item score is total of subscores for location, type and sharing of toilet or bath facilities.

[2]Item score is total of scores for items 16-19 inclusive. This duplicate score is not included in the total for a dwelling but is recorded for analysis.

[3]Item score is total of subscores for structure and dwelling unit.

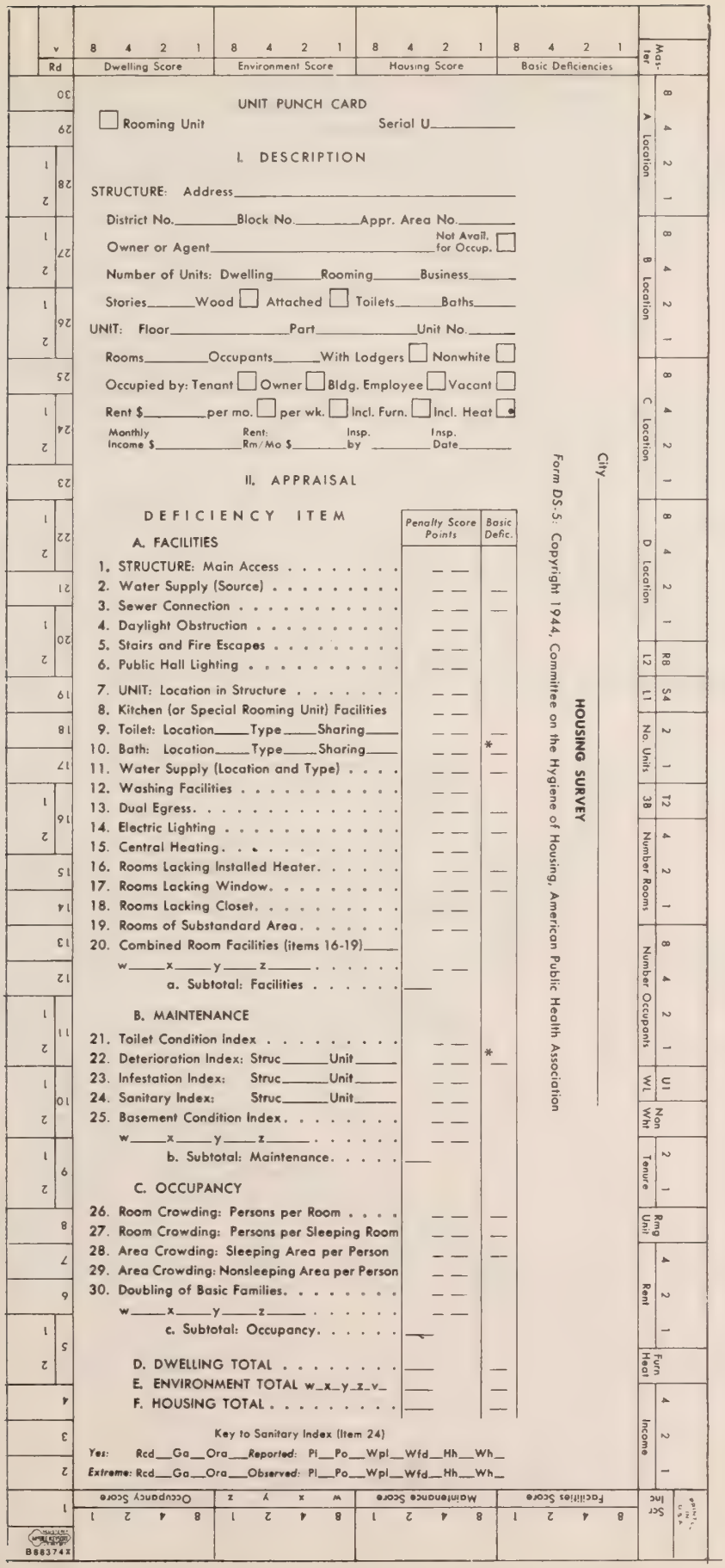

Fig. 12 Unit Punch Card

B L O C K A P P R A I S A L F O R M (Form E-4) - ENVIRONMENTAL SURVEY -

Housing Appraisal Technique of the Committee on the Hygiene of Housing, A.P.H.A.

IDENTIFICATION

Filled out by. _____
Date . . . . . _____
Checked by . . _____
Date . . . . . _____

Block bounded by: (name of street or other boundary)
1. _____
2. _____
3. _____
4. _____

District. . . . _____
Block . . . . . _____
. . . . . _____
Block . . . . . _____
D.U. Serial No_____ to No _____

I. RATINGS

ITEM	PENALTY SCORE Block Frontage 1		2		3		4	
A. LAND CROWDING								
1. Coverage by Structures								
2. Residential Building Density								
3. Population Density								
4. Residential Yard Areas								
Subtotal A								
B. NONRESIDENTIAL LAND USES								
5. Areal Incidence of Nonresidential Land Uses								
*6. Linear Incidence of Nonresidential Land Uses								
*7. Specific Nonresidential Hazards and Nuisances								
*8. Hazards to Morals and the Public Peace								
9. Smoke Incidence								
Subtotal B								
C. HAZARDS AND NUISANCES FROM TRANSPORTATION SYSTEM								
*10. Street Traffic								
*11. Railroads and Switchyards								
12. Airports								
Subtotal C								
D. HAZARDS AND NUISANCES FROM NATURAL CAUSES								
13. Surface Flooding								
14. Swamps or Marshes								
15. Topography								
Subtotal D								
E. INADEQUATE UTILITIES AND SANITATION								
*16. Sanitary Sewerage System								
*17. Public Water Supply								
*18. Streets and Walks								
Subtotal E								
F. INADEQUATE BASIC COMMUNITY FACILITIES								
*19. Elementary Public Schools								
20. Public Playgrounds								
21. Public Playfields								
22. Other Public Parks								
23. Public Transportation								
24. Food Stores								
*Item scored separately for each block frontage. Subtotal F								
TOTAL ENVIRONMENTAL SCORE Average for Block _____	Frontage 1 _____		Frontage 2 _____		Frontage 3 _____		Frontage 4 _____	
MEDIAN DWELLING SCORE Block . . . . . _____								
COMBINED SCORE Block . . . . . _____								

DESCRIPTIVE DATA

FSA-ATLANTA, GA.

Fig. 13. Block Appraisal Form

SHEET _____

STUDY _____

Readings _____ Entries _____ Date _____

	d	c	m	d	c	m	d	c	m	d	c	m	d	c	m	d	c	m
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
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Tabular Form DS-6: 1944, Committee on Hygiene of Housing, APHA

Fig. 14

Blank Form which, when filled in, resembles Fig. 15

RANGE OF TOTAL ENVIRONMENT SCORES BY APPRAISAL AREA:

Median Score and Class Range of Middle 50 Percent of Cases, All

Residential Frontages, by Appraisal Area by Quality Grade

SHEET 1 of 1 District 1 CHART 4-C

STUDY PHILADELPHIA HOUSING SURVEY, 1945

Readings FAT Entries FAT Date 6/14/45

Quality Grade: Number of Frontages / Appraisal Area	Grade E - 83				Grade D - 171					Grade C - 236			Grade B - 599					
	1	11	16	6	17	11	15	12	3	7	10	5	13	4	9	2	8	
Frontages in Area	11	23	27	22	11	22	46	24	66	44	119	74	77	150	151	100	121	
PENALTY SCORE	d	c	m	d	c	m	d	c	m	d	c	m	d	c	m	d	c	m
Class Points	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
12 120 - 129	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
11 110 - 119	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10 100 - 109	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
9 90 - 99	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
8 80 - 89	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
7 70 - 79	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
6 60 - 69	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5 50 - 59	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
4 40 - 49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3 30 - 39	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2 20 - 29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1 10 - 19	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
0 0 - 9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
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Tabular Form DS-6: 1944, Committee on Hygiene of Housing, APHA

Fig. 15. Range of Environment Total Scores by Appraisal Area

4. Maps are made of the various areas indicating, by shading, the relations elicited in Fig. 15. Together with pictures[1] of typical houses of various quality grades, and pictures of premises and neighborhood, this accumulated information aids the director and his staff to arrive at the most logical procedure to take in remedying the housing situation. The map in Fig. 16 shows block by block the quality of the dwelling conditions.

Scoring

Scores are the distinctive feature of the method and the key to its effectiveness. Some knowledge of the rating system and of the types of interpretation which it makes possible is therefore essential to an understanding of the survey procedures.

Method of Scoring. The scores consist of penalty points assigned to conditions that fail to meet a reasonable contemporary housing standard. The standards used have been adapted from the "Basic Principles of Healthful Housing," a formulation widely accepted by housing and public health workers as a reasonable statement of essential housing needs. Penalties rather than credit scores are used because the method measures departures downward from a base of acceptability. The scheme resembles a system of fines levied by a court of law: highest scores mean poorest conditions.

The penalty value assigned to each deficiency has been determined by consultation of members of the Committee on the Hygiene of Housing with others experienced in the fields of housing, public health, and city planning. Each reportable deficiency is graded according to the seriousness of that condition as a threat to health or safety or as an impairment of comfort or general livability, in the judgment of these experts. Thus the score assigned to each appraisal item represents a consensus of experienced persons as to the importance of that condition. The basis for the construction of the penalty scale is given in Chart 4 and on this basis the consultants fill out the form given in Fig. 17 for assigning penalty scores for each scorable item.

Factors of the dwelling or its environment which meet the standard receive a zero score. Penalties for individual deficiencies range from 1 point to a maximum of 30 points (See Charts 1 and 3). For example, scores of 20 to 30 points are assigned to conditions which offer extreme and everpresent threats to health or safety, such as overcrowding at the ratio of four persons per room or a single means of egress from a third floor unit in a tenement structure. A penalty of 10 points is charged for a toilet shared with another dwelling unit, or for five out of six rooms without heating facilities. Lesser deficiencies such as minor obstruction of daylight to neighboring structures, or closets lacking in part of the rooms of a dwelling unit, may be scored from 1 point upwards. Similar gradations occur in the environmental scores.

Under this scheme, a total score of zero penalty points for a dwelling unit and its environment indicates housing conditions which are excellent from the viewpoint of official agencies such as public health and building departments. Penalty scores as high as 30 or 40 points for dwelling and environment together may indicate a combination of minor deficiences which do not basically impair the livability of a house or neighborhood. Total scores in excess of 90 or 100 points, however, cannot be incurred under this scale except by a combination of basically substandard conditions that violate the fundamentals of decent living.

It should be stressed that enumerators do no scoring. Their only duty is to observe and record the facts as required on the field schedules. Scoring is done later in the office from templates and tables designed to speed the rating process.

It may be desirable to modify the standard scores in some details to fit local or regional conditions. For example, the values used in New England for inadequate heating facilities should be reduced for cities in the South. Adjustments of this type are facilitated by the complete separation of scoring from the collection of data.

1. It is good practice to take a photograph of a typical median dwelling or neighborhood in order that the office evaluation of the group may be aided. Photographs of the various quality grade dwellings and neighborhoods would also aid in the office evaluation.

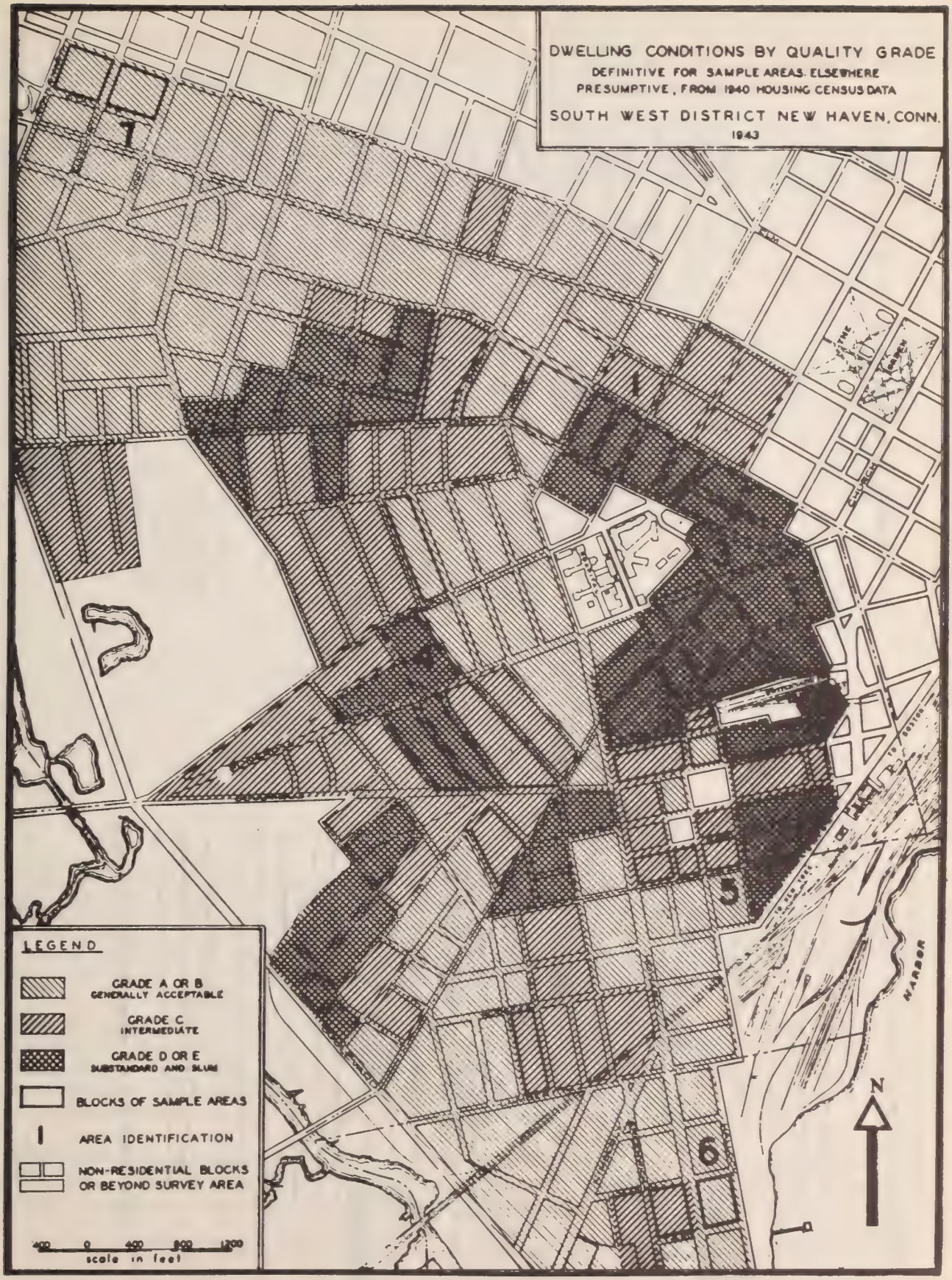
DWELLING CONDITIONS BY QUALITY GRADE
DEFINITIVE FOR SAMPLE AREAS. ELSEWHERE PRESUMPTIVE, FROM 1940 HOUSING CENSUS DATA
SOUTH WEST DISTRICT NEW HAVEN, CONN.
1943
LEGEND
GRADE A OR B GENERALLY ACCEPTABLE
GRADE C INTERMEDIATE
GRADE D OR E SUBSTANDARD AND SLUM
BLOCKS OF SAMPLE AREAS
AREA IDENTIFICATION
NON-RESIDENTIAL BLOCKS OR BEYOND SURVEY AREA
scale in feet
N
HARBOR

Fig. 16 Example of a Block by Block Map of an Appraisal Area

DEFINITION OF CLASS FOR ASSIGNMENT OF PENALTY SCORES BY CONSULTANTS ON SCALE-CONSTRUCTION

For each scorable item of the data schedules the consultant will complete a copy of the accompanying Form B. Conditions reportable under each item will be judged in terms of the detriments to health, safety or amenity which the consultant considers to be associated with those conditions. Assignments to the penalty classes shown on Form B will be made in accordance with the following definitions.

Penalty Class 0: Penalty 0 points.

Conditions essentially acceptable: i.e., those which involve no threat to or impairment of health, safety, or amenity with which any public agency need be concerned. (Slight impairments of amenity may be assigned to this class.)

Penalty Class 2: Nominal penalty 2 points; possible range 1 to 3 points.

Conditions which involve slight threats to or impairments of health or safety; or moderate impairments of amenity.

Penalty Class 5: Nominal penalty 5 points; possible range 4 to 7 points.

Conditions which involve moderate (considerable at some times or moderate at all times) threats to or impairment of health or safety; or considerable impairments of amenity.

Penalty Class 10: Nominal penalty 10 points; possible range 8 to 15 points.

Conditions which involve considerable and ever-present threats to health or safety; or extreme and ever-present impairments of amenity.

Penalty Class 20: Nominal penalty 20 points; possible range 16 to 30 points.

Conditions which involve extreme and ever-present threats to health or to life itself. (Extreme threats to moral well-being may also be assigned to this class.)

Chart 4. Basis for Construction of Penalty Scale

ASSIGNMENT OF PENALTY SCORES FOR ITEM OF C. H. E. APPRAISAL SCHEDULE: by _____ Initials

1. Schedule item: (Str.) (Unit) _____

2. Occurrence as recorded on schedule: Yes-No- ☐ Degrees ☐ Range or combination ☐

3. Probable extreme manifestation: _____

_____

4. Conditions detrimental to health, safety, or amenity (encircle which) deemed to be directly measured by this item: _____

_____

5. Preliminary classification of the extreme manifestation (3) as:

	Penalty Class: Points				
	0	2	5	10	20
a) Detriment to health, safety, or amenity for the affected family or in the reported structure only.....					
b) Additional detriment to families in nearby structures...					

6. Dependability of the schedule item as an index of the conditions noted in (4):

	A	B	C
	+	OK	-
a) Reliability of information as reported: exactness of measurement, objectivity, freedom from prejudicial attitudes, freedom from other concealed influences, seasonal variations in observed phenomena, etc.			
b) Constancy of significance of the item or conditions: as between various areas, dwelling or structure types, economic strata, family types, etc.			
c) Completeness with which the item reflects the conditions noted in (4)			

8. Relation of the item to other schedule items or scorable conditions:

a) Possible duplication of other items in penalty scoring _____

_____

b) Indirect value of the item as a measure of other conditions than those noted in (4) _____

	Penalty Class: Points				
	0	2	5	10	20
9. Final Classification of the extreme manifestation (3):					

10. Degree or manifestation to be assigned to Penalty Class 0: _____

_____

11. Remarks: _____

_____

Fig. 7. Form for Assignment of Penalty Scores by Consultants on Scale-Construction

Once the penalty scale has been adjusted and ratified for a given community the scoring of field schedules becomes a rapid mechanical process, requiring no further judgment on the part of the survey staff. A clerk can score a dwelling unit (with its containing structure) in three to four minutes, or at the rate of one hundred units or more per day.

Public Playgrounds; Public Playfields; Other Public Parks. These are listed as items 20-22 in the environmental survey (See Chart 1). Since the evaluation of these factors is usually not well known to sanitarians, a detailed penalty scoring outline is given below as a guide. (Chart 5.)

Chart 5. Penalty Scoring for Public Playgrounds, Playfields and Parks

Rating Tables:

20 *Public Playgrounds*

a) Walking Distance

Block Located	Pen Pts
Within Primary Distance Zone	0
Within Secondary Distance Zone	2
Beyond Secondary Distance Zone*	8

*Subsequent items not rated if block beyond secondary distance zone

b) Density of Use

Acres per 1000 Pers	Persons per Acre	Pen Pts.
0.75	0-1300	0
0.37-0.71	1301-2600	1
0.18-0.36	2601-5200	2
0-0.18	5200	3

c) Maintenance & Equipment

Reported Condition	Pen Pts.
Good	0
Fair	1
Poor	2

d) Supervision

Regularly Provided	Pen Pts.
Yes	0
No	1

e) Pedestrian Crossings

No. of Dangerous Crossings	Pen. Pts.
0-½	0
1-1½	1
2-2½	3
3 or more	5

MAX. COMBINED PENALTY: 8

21 *Public Playfields*

a) Walking Distance

Block Located	Pen Pts
Within Primary Distance Zone	0
Within Secondary Distance Zone	1
Beyond Secondary Distance Zone*	4

*Subsequent items not rated if block beyond secondary distance zone

b) Density of Use

Acres per 1000 Pers	Persons per Acre	Pen Pts
1.25	0-800	0
0.62-1.21	801-1600	1
0.30-0.61	1601-3200	2
0-0.30	3200	3

c) Maintenance & Equipment

Reported Condition	Pen Pts
Good	0
Fair	0
Poor	1

d) Supervision

Regularly Provided	Pen Pts
Yes	0
No	1

e) Pedestrian Crossings

Not rated

MAX. COMBINED PENALTY: 4

22 *Other Public Parks*

a) Walking Distance

Block Located	Pen Pts
Within Primary Distance Zone	0
Within Secondary Distance Zone	2
Beyond Secondary Distance Zone*	8

*Subsequent items not rated if block beyond secondary distance zone

b) Density of Use

Acres per 1000 Pers	Persons per Acre	Pen Pts
1.00	0-1000	0
0.50-0.99	1001-2000	1
0.25-0.49	2001-4000	2
0-0.25	4000	4

c) Maintenance & Equipment

Reported Condition	Pen Pts
Good	0
Fair	1
Poor	2

d) Supervision

Not rated

e) Pedestrian Crossings

No. of Dangerous Crossings	Pen Pts.
0-½	0
1-1½	1
2-2½	2
3 or more	4

MAX. COMBINED PENALTY: 8

Public Playgrounds are public open spaces designed and equipped for the play of children of any ages between 6 to 15 years inclusive. School playgrounds are to be included only if they be open after school hours and if the attendance be not restricted to children enrolled in the school. Sections of playfields or other public parks are included if they be developed as children's playgrounds, but only the acreage devoted to this specific purpose should be counted.

Playfields are public open spaces developed for diversified recreation of young people and adults and may include a variety of features such as sports areas for football, baseball, soccer, tennis, bowling, swimming, etc. Athletic fields of schools should be included only if they be available for general community use and if they afford a variety of facilities. In case a playfield is part of a larger area, only the acreage devoted to playfields should be included.

Other Public Parks include all public open spaces other than playgrounds and playfields, if they be landscaped and provided with facilities for the recreation of adults. Small greens with benches, as well as large parks, are to be included here.

This survey is limited to public open spaces, and does not include such spaces as provided by churches, private social agencies, and other semi-public organizations.

Basic Deficiencies. An auxiliary score is provided by designating basic deficiencies in dwellings. A basic deficiency is a lack of dwelling facilities, disrepair, or a degree of overcrowding so serious that is has been widely recognized by public health and housing agencies as:

a. Calling for a correction order by a local enforcement agency, or
b. Justifying the removal of the affected family to other quarters if the condition be not or cannot be remedied in their present home.

In other words, a basic deficiency is a major substandard condition in the sense that progressive city and state housing regulations acknowledge it as warranting drastic corrective action by the municipality. Examples of basic deficiencies are lack of dual egress, a toilet outside the structure, and sleeping area of less than 40 square feet per person. The deficiencies which, in extreme form are counted as basic deficiencies are indicated by entry lines in the column at the right of the Unit Appraisal Form, Fig. 10. Exact specifications of the basic deficiencies are given below. Lesser forms of deficiency for these appraisal items carry small penalty scores and are not counted as basic deficiencies.

Condition Constituting a Basic Deficiency of a Dwelling.

Item (Numbers refer to deficiency items of Unit Appraisal Form, Fig. 10)

Facilities
2. Source of water supply specifically disapproved by local health department.
3. Means of sewage disposal specifically disapproved by local health department.
9. Toilet shared with other dwelling unit, outside structure or of disapproved type (flush hopper or nonstandard privy)
10. Installed bath lacking, shared with other dwelling unit or outside structure.
11. Water supply outside dwelling unit.
13. Dual egress from unit lacking.
14. No electric lighting installed in unit.
16. Three-fourths or more of rooms in unit lacking installed heater.[1]
17. Outside window lacking in any room of unit.[1]

Maintenance
22. Deterioration of class 2 or 3 (penalty score, by composite index, of 15 points or over.)

Occupancy
26. Room crowding: over 1.5 persons per room.
27. Room crowding: number of occupants equals or exceeds two times the number of sleeping rooms plus 2.
28. Area crowding: less than 40 square feet of sleeping area per person.

Because there is less widespread recognition of environmental problems than of dwelling defects, it has not yet been possible in the environmental appraisal to designate basic deficiencies which would be acknowledged by official agencies as requiring remedial action.

Thus a dual criterion of adequacy is provided: the penalty score and the designation of individual defects that make a house substandard, regardless of the total score.

Interpretation: Quality Grades. A weakness of housing surveys has often been that when the results were presented it was difficult to tell what they meant and what should be done about them. A non-scoring system is likely to result in a bewildering array of maps, tables, and graphs which fail to give a summary picture that would be understood by the busy public official or the layman.

Under the present method, a small number of maps and tables will show both the relative quality and the specific problems of areas studied. The procedures for analysis and presentation of results take full advantage of the fact that a scoring system expresses complex relationships in a single figure, making it possible to consider broad findings before proceedings to details.

The data are prepared for interpretation by the following primary steps:
1. Each dwelling unit is rated by totalling the penalty scores for all deficiency items of

1. The criterion of basic deficiency for this item is adjusted for number of rooms in the unit.

that unit and of the structure which contains it, and by totalling basic deficiencies.

2. Environmental scores are computed by blocks, with some items (such as exposure to traffic hazard) varying as between the four street frontages of a block.

3. Total housing quality is expressed by adding to each dwelling unit score the environmental score of the street frontage on which the dwelling lies. The term "housing quality" is used only when dwelling scores and environmental scores have been combined.

For convenience in comparison, areas are then classified into quality grades on the basis of their characteristic penalty scores. These grades may range from A to E for dwelling conditions and environment separately, and also from A to E for total housing quality (dwellings and environment combined.)

Dwelling conditions can be classified into quality grades either by penalty scores or by the prevalence of basic deficiencies. The former is necessarily used where dwelling results are to be combined with environmental findings to produce a classification of total housing quality. For dwelling results alone, however, classification by basic deficiencies has a possible advantage. By assigning to grade D those areas where 50 to 75 percent of the dwelling units show basic deficiencies (officially recognized substandardness) the term Substandard can be made a part of the grade designation. The term Slum can be similarly used in connection with Grade E, where 75 percent or more of the dwellings are substandard in this sense. Thus a quite precise meaning can be given to terms which are familiar to the layman.

Classification of dwelling results is usually little affected by the choice in method of quality grade classification, since the ratio between penalty scores and number of basic deficiencies generally shows a high degree of consistency.

Table 8. Class Intervals for Determination of Quality Grades of Appraisal Area or District

Quality Grade	Median Score of Appraisal Area or District		
	Dwelling Score	Environment Score	Housing Score
A	0 - 29 points	0 - 29 points	0 - 59 points
B	30 - 59 "	30 - 59 "	60 - 119 "
C	60 - 89 "	60 - 89 "	120 - 179 "
D	90 - 119 "	90 - 119 "	180 - 239 "
E	120 and over	120 and over	240 and over

Grade A signifies good to excellent housing which will usually be entirely free from basic deficiencies and have only a scattering of minor defects. Grade E marks the thoroughgoing slums where multiple deficiencies will be almost universal and where a substantial percentage of dwelling units may show two or three basic deficiencies apiece. Grade D will indicate the areas just better than the poorest which have wide-spread deficiencies and serious obstacles to rehabilitation; Grade C, the mediocre housing districts in which extensive blight and obsolescence can be expected. Into Grade B will fall those neighborhoods which, while not the most modern or fully up to standard, are still essentially free from serious problems.

Within this framework of quality grades, analysis of total scores reveals the relative seriousness of combined deficiencies as between one area and another, together with the range of conditions in each area. The broad nature of deficiencies is indicated by the distribution of subtotal scores (facilities, maintenance and occupancy for dwellings; land crowding, mixed land use, etc. for the environment). Beyond this, specific problems and the kind of concrete action needed are revealed by analysis of scores for individual deficiencies of dwellings or environment.

Such analysis is possible not only by areas but also by descriptive classifications. Problems which vary by race of household, size of family, class of rent, type of structure and similar factors can be explored with great economy by comparing characteristic scores.

Plan for Immediate Action

The time is indeed ripe for every health department to begin working out a housing program. This does not mean that they should start thinking about the program now and take action "some

time in the future." There are several types of activities that can be set into immediate motion.

1. Systematic inspection and re-inspection of houses by the health department for unsanitary conditions, in coordination with inspection of structural deterioration by other official departments such as building, fire, and public safety departments.

Rejuvenation of law enforcement in respect to housing to the maximum extent that the present laws allow.

2. Formulation of an official minimum housing standard below which dwellings should be closed or demolished as fast as new construction or rehabilitation is possible. This means that surveys in slum areas should begin immediately according to the principles of the Committee on Hygiene of Housing. This should be done in cooperation with other related official agencies.

3. New legal controls should be set up to apply to all houses instead of just tenements, rooming houses, hotels, business houses, and factories. Slum clearance regulations should be adopted to cope with modern conditions. Overcrowding regulations and rent control boards should be initiated.

4. Planning for future low-rent housing facilities should be started. The method of financing such a program will offer challenging problems. Government subsidies and private capital should both be utilized when possible.

5. A housing educational program should be initiated immediately. The program adopted should fit the circumstances. An acquaintance with the Baltimore housing education program may be of help.

6. Organization of a local planning board to work in cooperation with State and Federal planning Boards would facilitate matters. Every community should have an over-all plan for future development and expansion. The mushroom, haphazard character of developing subdivision areas should become an anachronism as soon as possible.

Basic Principles of Healthful Housing

A. Fundamental Physiological Needs

Principle 1. Maintenance of a thermal environment which will avoid undue heat loss from the human body.

a. Specific Requirements. The four factors controlling heat loss from the human body are air temperature, mean radiant temperature of surrounding surfaces (walls, windows, radiators, human bodies, open fires), relative humidity, and air movement. In an ordinary dwelling, under winter conditions, air temperature and mean radiant temperature are the chief variables, since neither air movement nor humidity is likely to be considerable. The combined effect of air temperature and mean radiant (or wall) temperature is defined as "operative temperature." For ordinary dwelling conditions, operative temperature may be taken as approximately the mean between air temperature and wall temperature. For the normally vigorous person, normally clothed, and at rest, an operative temperature of 65° F. is the minimum. In all regularly occupied rooms this temperature should be provided at knee-height, 18 inches, in order to prevent chilling of the legs and feet. Air temperature may be increased or decreased in order to compensate for deviations of mean radiant temperature above or below air temperature.

In rooms occupied by persons of subnormal vitality, operative temperatures must be higher than 65° F. Since dwellings should be designed for occupancy both by old people and by young children who may play on the floor, the heating system should be able to provide an operative temperature of 70° F. at knee-height under ordinary winter conditions. Such a temperature may however, be unduly high for the normal adult and need not necessarily be maintained.

Considerable vertical differentials of air temperatures are highly undesirable, since they involve waste of fuel (from increased heat loss through the upper areas of the room), and since they not only produce local chilling of the lower extremities, but also increase convection currents. With ideal heating, ankle-height temperatures and 5 foot temperatures would be almost identical. Unfortunately, however, temperatures at ankle-height are often 65° F. with 70° at 5 foot levels

and 80° at ceiling height: a total differential of 15°. In very poorly heated houses, differentials of 30° and more have been observed.

No temperature conditions are ideal unless they can be held reasonably constant when desired, regardless of unpredictable changes in weather. It is equally important, however, that quick changes in temperature be possible to meet emergency requirements.

b. Methods of Attainment. The practical measures to be taken in housing design to meet these needs must, of course, depend upon climate, but it should be possible to reach the limiting temperature of 70° F. at knee-height under ordinary minimum winter conditions for the locality concerned. The usual figure for outside temperature taken by engineers as a basis for their computations is 15° F. above the lowest recorded temperature for a ten-year period.

The heating equipment provided will also, of course, be closely related to the insulation of the building. Superior types of construction, weather stripping and the use of double windows, and the use of insulating materials in ceilings and walls may, in cold climates, reduce heating costs by 50 percent or more. Such insulating capacity should, therefore, be provided as is justified by fuel economy balanced against additional construction costs. The balancing of these factors is a problem deserving special study.

Insulation, as normally used for heating economy, has a particularly beneficial effect in reducing temperature gradients or differentials from floor to ceiling. Customary differentials ranging from 10° to 20° between floor and ceiling in an uninsulated house may be reduced below 10° when insulation is installed.

For low-rent housing in one- or two-story dwellings, the freestanding circulating heater type of stove will generally prove the most economical heating equipment, although frequently yielding poor conditions of thermal comfort. Current experiments in low-cost dwellings indicate that such a circulating heater, when enclosed in a central distribution chamber, discharging warm air to adjacent rooms through grilles, may produce thermal conditions superior to those associated with a free-standing circulator. For apartments, and perhaps for large groups of one- and two-family houses, steam heat from a central plant should prove as economical as stove heat. Central heating cannot wisely be replaced by stoves in the multi-story dwelling because of fire hazard and the problems of fuel storage and ash disposal.

For certain installations, hot water heating may have advantages. Indirect heating by hot air may also be employed. Where indirect heating involves considerable air change, permissable lower limits of temperature may have to be raised (to balance increased rates of convection loss from the body.)

The ideal condition of almost identical temperatures at ankle-height and 5 foot level can be obtained by radiant heating, with the use of large area units installed in the floor or placed low in the wall around two or three sides of the room. The possibilities of low temperature radiant heating by steam or hot water or, where power rates are low, by electricity, should be given careful consideration.

Thermostats are the most effective means of obtaining constant temperatures. At least one thermostat per dwelling unit should be considered where the cost may be justified by probable fuel economy. It is imperative, however, that manual control of thermostats and heat sources also be available in each dwelling unit. Different families usually prefer and often require different temperatures to meet special needs.

Flooring materials of high heat-conducting value should be avoided, particularly where children may play upon the floor. Loss of body heat by radiation to windows may be controlled by curtains. Excessive dampness combined with low temperature will increase heat loss from the body and may cause chilling, but this condition is not common in the United States.

It should be particularly emphasized that bedrooms need not always be maintained at 65° F. when unoccupied or when occupied for sleeping.

If intermittent radiant heating be available the bathroom may also be maintained at a lower temperature. Additional local heating units, on the other hand, may be necessary in rooms occupied by persons of subnormal vitality.

Principle 2. Maintenance of a thermal environment which will permit adequate heat loss from the human body.

a. Specific Requirements. The factors involved here are, again, air temperature, mean radiant temperature of the surrounding surfaces, relative humidity, and air movement. In cold weather, air movement and relative humidity inside the dwelling will normally be low, and the determining factor will be operative temperature, which should not exceed 75° F. within the zone of occupancy. In warm weather, humidity will decrease the limit of tolerance, and air movement will increase it. The human body is of course acclimated to higher temperatures in summer than in winter.

It is particularly important that cool moving air be made available in sleeping-rooms, since the impact of cool air is of great value in promoting healthful sleep.

b. Methods of Attainment. Overheating in the winter season is all too prevalent in modern housing. It should be possible to eliminate this condition through adequate controls of local heat sources with a minimum use of windows. In the case of steam-heated dwellings, both effective operation of central heating plants and a maximum of individual control of heat supply to each room are essential for satisfactory results. In large buildings and in housing projects, zone control of the steam supply produces greater efficiency.

In summer, air cooling and air dehumidification are valuable adjuncts to comfort, but are beyond the present economic limits of the low-rent dwelling. In the free-standing house, the installation of an exhaust fan at the top of the house to draw in cool night air through windows is also an extremely helpful procedure. It would seem not unreasonable to include in the equipment of the home at least one electric fan for cooling, in regions where summer heat is considerable.

Even in the low-rent home, we must insist on adequate through- or cross-ventilation. Windows should be so placed as to assure adequate circulation throughout each room, and their open area should extend close to the ceiling, within 6 inches if possible, to permit hot air in the upper part of the room to escape. Windows of the casement type which swing either horizontally or vertically may be superior to the double-hung type if their entire area be made effective for ventilation. An additional advantage of the swinging type of sash is the possibility of controlling the direction of circulation by setting the angle of its panels. Heat loss by infiltration around window casements during the winter should also be considered in the selection of type of window. All double-hung windows should open at top and bottom. Adequate window area and careful placement of windows are especially important in kitchens, to remove heat resulting from cooking.

Exposure to prevailing summer winds is a major factor in securing comfort through high air movement during hot weather. Both warming in the winter and cooling in summer are materially aided by suitable orientation of the dwelling toward the sun, as discussed under Principle 5. Summer sunshine, especially in the late afternoon, may be extremely undesirable, particularly in small apartments where all of the rooms face in one direction. This factor renders an unobstructed west or northwest exposure unfortunate since there is practically no means of excluding sun heat falling on walls facing in this direction during the late afternoon in the early summer.

Principle 3. Provision of an atmosphere of reasonable chemical purity.

a. Specific Requirements. The important atmospheric impurities present in the home under ordinary conditions are those contributed by cooking, by various heat sources, and those derived from the human body. When windows are open, fumes, odors, and soot from neighborhood sources may be present. (Hazards from heating sources and those associated with special toxic gases are considered under Principle 28).

The odors given off from the body have been proved to exert a definitely harmful influence upon appetite and therefore upon health. With persons of reasonable cleanliness the dilution of these odors will require an air change of 10 cubic feet per person per minute.

b. Methods of Attainment. Such an air change as this, with any ordinary type of construction, will be automatically attained in cold weather by normal leakage through walls and ceilings of ordinary porosity and around normally constructed doors and windows, provided the cubic space per occupant is 400 cubic feet in any occupied room, and that the normal ratio of fenestration be supplied. The necessary air change can be secured in summer by the opening of windows. Since this minimum of 400 cubic feet is demanded by other fundamental needs to be discussed in later sections, no other provision for air change need ordinarily be made in the low-rent dwelling. If the other fundamental needs could be met, and if dependable artificial ventilation were provided, a lesser air space might be permissible.

It should be noted that this standard of 400 cubic feet applies to any occupied room. Where separate rooms are used for living and sleeping, the total for the habitable portions of the dwelling must be 800 cubic feet per person. Where this total volume for the dwelling as a whole is provided, it may be unobjectionable to permit space in sleeping-rooms to fall somewhat below the 400 cubic foot standard, provided that functional arrangement of furniture be not interfered with. Where the same room is used for both living and sleeping, the value should be increased from 400 cubic feet to at least 500 cubic feet to allow for necessary furniture. [1]

Ceiling height may, in general, be determined by cubic space requirements and by necessary window heights.

Noxious fumes and odors, and unpleasant soot and grime from industrial and other neighborhood sources are not always subject to effective control under regulations governing nuisances. Their presence in the neighborhood and the direction of prevailing winds which carry them are factors which should be considered in the choice of housing sites.

Principle 4. Provision of adequate daylight illumination and avoidance of undue daylight glare.

a. Specific Requirements. In order to avoid danger of eye strain and facilitate cleanliness, the minimum light value available for any occupied space relying upon natural illumination should be 6 foot-candles, measured on a horizontal plane 30 inches above the floor. Windows should be so placed in the rooms of a dwelling as to afford the greatest illumination possible, without glare or shadows, for the optical tasks that are expected to be performed at certain locations in these rooms.

b. Methods of Attainment. With unobstructed exposure to the sky, the minimum illumination defined above will be obtained in clear weather and up to a reasonable time before sunset (in the latitude of Washington, D.C., 39°) with an area of window glass equal to 15 percent of the floor space of a room (provided that walls and ceiling are light in color.)

For locations in the United States other than Washington, D.C., the minimum window area can be either increased or decreased in proportion to the average brightness of the sky in the locality. This brightness will depend in any locality upon the latitude, altitude, amount of air pollution, and relative humidity of the region. Figures for the daylight illumination and brightness of the sky for different regions and latitudes of the United States which have been given by the Weather Bureau and the United States Public Health Service show that for the same latitude the average daylight illumination is about 25 percent higher for the Plains states (those lying between the Mississippi River and the Rocky Mountains) and about 46 percent higher for the Plateau states (those lying between the Rocky Mountains and the Sierra Nevada and Cascade Mountains) than for the Eastern states. It is possible, therefore, that for the same latitude in Plains and Plateau states the necessary window area may be less than in the Eastern States.

To correct for latitude, the area of the window might perhaps be increased by about 2 percent of its own value at 39° for every degree north of that latitude, and decreased by about 2 percent of its own value at 39° for every degree south of that latitude. Thus, at 45° latitude, the required window area would be increased by about one-eighth, or to approximately 17 percent of the floor area. These recommendations assume a generally clear atmosphere and normal horizons.

Buildings must be spaced sufficiently far apart so as not materially to obstruct sky shine. It seems reasonable to require that the sky angle at the lowest window sill be not less than 45°,

1. The Subcommittee on Standards of Occupancy of the Committee on the Hygiene of Housing is making a special study of space requirements, looking toward a revision of the 400 cubic foot standard.

which implies that the width of intervening street or court space should approximate at least the height of opposite buildings. The loss of light due to the obstruction of the sky by opposite buildings. The loss of light due to the obstruction of the sky by opposite buildings may, however, within limits, be approximately compensated for by an increase in the ratio of the glass area of the window to the floor area by 1 percent for every 4° decrease in the sky angle. Thus, the glass-area floor-area ratio for sky angles from 90° to 85° would be equal to 15 percent; from 82° to 78° to 17 percent; etc. Since it is desirable, from the viewpoint both of ventilation and of lighting as discussed below, that the tops of windows be as near to the ceiling as is structurally possible, the proposed increase in the area of the windows should be obtained by increasing their width.

All rooms, including bathrooms, should have at least one window opening to the outer air (except in the case of specially lighted and ventilated bathrooms in hotels and such large multi-family dwellings as have ample economic resources for maintenance and domestic servicing.) Daylight illumination should be provided for public halls and stairs, except perhaps in elevator apartments with adequate janitor service.

It is of advantage to have the tops of windows as near to the ceiling as possible, to give the greatest sky angle in all parts of the room and thus to secure the greatest lighting effectiveness. Kitchen windows especially should be so located as to supply light without shadows for the performance of culinary tasks. Inside walls of a good reflecting value (reflection factor at least 50 percent) are essential factors in obtaining the desired result. Glossy paint should be avoided on account of glare; ceilings should be matt white or of a lighter color than the walls (reflection factor at least 70 percent). The finish of wall and ceiling surfaces should be such as to facilitate cleaning, in order to retain original reflecting values.

For control of glare, suitable window shades are essential; those of the Venetian blind type, although costly and difficult to keep clean, are desirable, since they protect from the glare while reflecting light to the inner part of the room. Windows extending below 30 inches from the floor tend to cause glare and obstruct furniture placement without materially increasing general illumination.

Rooms having windows which face covered porches should be supplied with more than the normal ratio of glass area. The darkening effect of porches can be reduced by the finishing of porch ceilings with colors having high reflecting values.

It should be noted that good natural lighting is often interfered with by internal obstructions, such as draperies and furniture. It would be of advantage, where available light is near the desirable limit, so to place curtain rods that draperies may be hung adjacent to, rather than over, the windows.

Principle 5. Provision for admission of direct sunlight.

a. Specific Requirements. No definite quantitative limits can be set; but it is clearly desirable for all dwellings, and essential for those occupied by persons who are housebound, that direct sunlight should enter at some places and hours, especially in winter. Sunlight, particularly through its ultra-violet components, provides valuable physiological stimulation.

b. Methods of Attainment. Insolation in a given room depends on sky angle as related to that area of the sky occupied by the sun's orbit at a given season. It will be materially influenced by the orientation of buildings and by their spacing as discussed under Principle 4, by adjacent buildings or projections so located as to cut off the early morning and late afternoon sun, and by the placement of windows in the various rooms.

In the northern latitudes of the United States, a generally southerly orientation of rooms for daytime occupancy is most desirable since it gives a maximum of sunlight in winter. In order that sunshine may penetrate to the yard on both sides of a row structure, however, it is desirable that such structures be oriented to face about 20° or at the most 30° either east or west of south. In this connection it should be noted that streets running directly east and west suffer a great disadvantage, since their surfaces receive a minimum amount of sunlight - perhaps none at all - during the winter months, because of the shadows of buildings on their southern frontage. Ice

and snow may remain frozen on such streets for long periods. Streets which run northeast-southwest or northwest-southeast, however, will receive some sunlight during every clear day of the year.

Within buildings which are properly oriented to the sun, the locations of individual rooms should be studied to provide desirable insolation during the hours of their use. If the living-room and kitchen —the rooms most occupied during the daytime —face the southeast rather than the southwest, they will receive their summer sun at a relatively cool time of day.

Utilization of the sun's heat in winter to lessen the costs of heating is an important possibility which has been little explored. Experimental work by Henry N. Wright has indicated that rooms or dwellings which supplement a southerly exposure with large window areas may require virtually no artificial heat on clear winter days, even in northern climates. The effectiveness of such natural heating depends on adaptation to local meteorological conditions. The relation of orientation to local meteorological conditions should be studied for various areas.

In determining the orientation of buildings, it should of course be borne in mind that exposure to prevailing summer winds is essential to comfort, and that compromises between ideal orientation toward sun and wind, respectively, may be necessary.

In rooms which have east or west exposures, placement of windows as far to the south as practicable will favor maximum penetration of sunshine.

Casement windows which open substantially throughout their area are more desirable than double-hung windows from the standpoint of admitting the ultra-violet rays of sunlight.

Principle 6. Provision of adequate artificial illumination and avoidance of glare.

a. Specific Requirements. Artificial illumination of 6 foot-candles should be generally available over 25 percent of the floor area in each occupied room,[2] with at least 15-foot candles of local illumination at certain points for reading, study, or sewing. Illumination of at least 1 foot-candle should be provided on stairs and in passageways to minimize danger of accidents. Glare effects should be avoided in the design and location of fixtures.

b. Methods of Attainment. The maintenance of the illumination specified above, and the avoidance of accident hazards due to oil lamps, can be attained only by the use of electricity. Electric lighting should be considered a minimum requirement for the healthful American home.

There should be a central outlet in the ceiling of each room, with at least two convenient outlets in the living-room and at least one in each of the other rooms. In the kitchen, shadows on the sink and work table should be avoided, if necessary by installing a second fixture. In the bathroom the central fixture may be replaced by lighting adjacent to the mirror.

For the control of glare, all bulbs should be shielded from view by suitable globes or translucent reflectors or shades, so that the brightness contrast between the light source and its adjacent background does not cause visual discomfort. Ceiling fixtures providing semi-indirect lighting are highly satisfactory sources of general illumination, and floor lamps of the direct-indirect type supply an excellent balance of local and general illumination. The shades of table and floor lamps should be of sufficient thickness and of such color that their surfaces will not be a source of glare when the lamps are lighted. Translucent globes providing direct lighting often produce uncomfortable brightness contrasts, but when located close to the ceiling out of the normal field of view, may be satisfactory in kitchens and bathrooms. All fixtures and bulbs should be cleaned periodically to retain lighting efficiency.

Sleeping-rooms should be protected from external artificial light sources such as street lamps and electric signs.

Principle 7. Protection against excessive noise

a. Specific Requirements. Excessive noise, a factor much neglected in the United States, is of serious moment in so far as it causes nerve strain and interferes with sleep and other

2. The Subcommittee on Illumination of the Com. on the Hygiene of Housing is making a special study of general illumination requirements, looking toward a revision of this 6-foot-candle standard.

physiological processes. It should be possible to exclude noises from outside the dwelling unit to such a degree that within that unit the noise level shall not exceed 50 decibels; and a level as low as 30 decibels should be attainable in rooms used for study or sleeping. These standards are based on European practice and call for further examination under conditions in America, where the prevalence of radios and automobiles raises new and serious problems.

b. Methods of Attainment. The solution of this problem depends, first of all, on the control of external sources of noise, which involves the avoidance of dwelling sites with exposure to special sources of noise (factories, highways, railroads, athletic fields, and the like), and the control of motor horns and radios. Small enclosed courts should be avoided in housing developments, since noise may be reflected from the building walls.

For control of noises transmitted by air within a multi-family dwelling, party walls should effect a reduction of about 50 decibels (approximately the result produced by an 8 inch brick wall). Apartment doors opening onto public passageways should be fitted so as to exclude noise.

For the control of structure-borne noises, floors and ceilings should be constructed to effect a reduction of 15 decibels of impact noise. Such a floor will be adequately insulated against air-borne noise. Construction consisting of two thicknesses of wood flooring on standard joists, with lath and plaster ceiling, usually effects a reduction of 10 to 15 decibels. If the laths or ceiling boards be fastened to the joists with spring clips and the floor be laid so as to permit a small amount of "play" between the sub-floor and the joists, a reduction well above 15 decibels may be obtained. Concrete floors, although adequate for the reduction of air-borne noise, normally effect no reduction in impact noises such as footsteps, scraping of chairs, etc. All plumbing, steam pipes, and valves should be correctly designed, so that steam "hammer" and "singing" valves cannot occur. Refrigeration and heating equipment, pumps and blowers should be so installed that their vibration cannot be transmitted through the dwelling structure. Plumbing stacks should preferably not be located in living-room or bedroom walls.

Principle 8. Provision of adequate space for exercise and for the play of children.

a. Specific Requirements. Opportunities for physical exercise and recreation, for both children and adults, are essential to a sense of organic well-being and the enjoyment of mental health. While these ends may be considered as primarily psychological in nature, they are attained by physiological processes and may therefore be considered under the present category.

The attainment of the purposes indicated requires consideration of the reciprocal relations between internal space for social use and area within the dwelling, and outside space suitable for organized recreation, meeting the needs for different groups and sexes and located so as to serve their convenience with the greatest possible economy in construction and maintenance.

Standards for outdoor recreation areas in new housing developments have been the object of careful study by a committee appointed in October, 1938, by the National Recreation Congress. This committee has since published a report, entitled "Play Space in New Neighborhoods," which provides a sound basis for estimating local neighborhood needs where the characteristics of the population and of the area to be served are known. While it is probable that the standard commonly cited (10 acres per 1,000 persons for all types of recreational areas, including metropolitan regional parks and reservations) may not be excessive when applied on a city-wide basis, it is obvious that local needs for recreation space can be met only after a detailed study has been made of specific neighborhood requirements. A study of the recommendations of the committee appointed by the National Recreation Congress indicates that the area needed for local playgrounds and playfields (including playlots for children of preschool age) varies from about 2 1/2 acres per 1,000 persons, in the case of a neighborhood housing 1,800 families, to 3 acres per 1,000 persons for a neighborhood of one-third this population (assuming in each case the same age group composition and family size). In a neighborhood of 1,800 families with a population density of 10 families per gross acre, such a standard would require the setting aside of 10 percent of the area for this purpose, whereas a density three times as great would increase the proportion of open space required for active recreation to 30 percent of the gross area.

b. Methods of Attainment. For city dwellers it has been suggested that the recreation

area should include a playground within such distance as to be practically accessible, and an athletic field within half a mile of each home for the use of adolescents. It is desirable to provide play spaces for very young children (separate from those of adolescents) within each block or large group of dwellings, so as to facilitate parental supervision and minimize traffic hazards.

Planning for recreation is obviously a problem in city or neighborhood planning, and the optimum size and effective radius of indoor and outdoor recreational facilities will greatly influence the determination of neighborhood boundaries. Not only must the physical characteristics of the neighborhood be recognized, but also the varying needs of the people to be served. This implies knowledge of the characteristics of the population (preferably classified by age, race, occupation, and economic and social status) and the relation of these characteristics to individual and group recreation habits.

The subject of standards for recreation space is receiving further study by this Committee.

It should be emphasized that provision of recreation facilities is by no means necessarily a function of housing authorities. Such facilities are logically chargeable to the community as a whole, rather than to a specific housing project. Yet is is clearly the responsibility of the housing authorities to be certain that such facilities be or will be available before approving a housing scheme. In large urban developments the management may make provision for trained leaders of club and recreational activities if such service be not otherwise available.

B. Fundamental Psychological Needs

Principle 9. Provision of adequate privacy for the individual

a. Specific Requirements. The essential concept of a home involves the possibility of that isolation from the world which every human being sometimes craves and needs. Especially in cities, the home is a needed refuge from the noise and tension of the street and market place. The same principle applies within the home itself. When the dwelling unit is crowded, frequent personal contacts may be the cause of nervous irritation, as detrimental to mental health as is more obvious influence of contact infection upon physical health. "A room of one's own" is the ideal in this respect; but we can at least insist on a room shared with not more than one other person as an essential minimum. Such a room should be occupied only by persons of the same sex except for married couples and young children. The age at which separation of sexes should occur is fixed by law in England at 10 years, but some American authorities would place the figure 2 years lower. Sleeping-rooms of children above the age of 2 years, according to psychiatric opinion, should be separate from those of parents.

Furthemore, fundamental habits of decency demand that toilets, bathrooms, and bedrooms should be accessible from halls or living rooms without passing through other bedrooms or bathrooms.

Dwellings should be so spaced on their sites, and their windows so located, as to limit direct vision from one dwelling into the bedrooms and bathrooms of another.

b. Methods of Attainment. The objectives stated can be attained by various types of design, but they imply in practice at least the standards enforced under the current English legislation on overcrowding. Under this legislation, not more than 2 persons may occupy a sleeping-room. Two rooms are required for 3 persons, 3 rooms for 5 persons, 4 rooms for 7 1/2 persons, and so on. Bathrooms and sculleries are not counted as rooms. For the purpose of governing occupancy, infants under 1 year of age are not counted, and children between 1 year and 10 years are counted as half-persons.

It is desirable to provide sleeping space apart from the living-room, but when this cannot be done, the living-room must be provided with reasonable privacy, as outlined above.

Overcrowding cannot be prevented either by proper physical planning alone or by good planning plus care in the initial selection of tenants. It is also necessary that continuing supervision be exercised and that adjustments to changing family needs be made by management authorities. Limitation of boarders, control of subleasing, intelligent adjustment of rent schedules of family size and income, sympathetic handling of transfers or other problems due to changing family size

or income are all involved in maintaining desirable conditions of privacy.

Principle 10. Provision of opportunities for normal family life.

a. Specific Requirements. Privacy is one element in normal family life; but sociability is another, which is psychologically and socially quite as important. Opportunity for adolescent youth to meet persons of the opposite sex under wholesome conditions should be provided. To meet these needs a common living-room which can be occupied by all members of the family, plus reasonable space elsewhere for withdrawal during periods of entertainment, would seem essential. In situations where space within the dwelling unit must be restricted to the minimum required for everyday routines of the family, it is desirable to supply supplementary facilities, outside of the dwelling unit, which will accommodate the occasional or extraordinary needs of the family (such as entertaining and ceremonial observances) which would tax the capacity of the home and might lead to friction within the family or with neighbors. The characteristic needs of large, small, and specially-composed households must be met. It is important for the establishment of friendships and the striking of family roots in the chosen community that continuous residence in that community should be possible through all the normal changes in family size and make-up; such continuity should be fostered by the provision in every housing development of living units adapted to families of various sizes and types.

b. Methods of Attainment. Living space in the dwelling unit must be so organized as to provide a suitable gathering-place for members of the household and their guests. Whether this space be provided in the form of a separate living-room or, as may sometimes be desirable, in the form of combined kitchen and living-room, it is necessary that 400 cubic feet of living space be supplied per person, as specified in Principle 3.[3]

To design the home merely in terms of the recognized room labels - "living-room," "first bedroom," "kitchen," etc. --offers no guarantee that the functional needs of the family will be met. The functions themselves must be clearly visualized and provided for in terms of the social group which it is proposed to house. Provision must be made for group activities of the family, such as reception of visitors, recreation, and reading; for withdrawal of individuals for study or rest during periods of family activity; for sleeping, with its related functions of clothing storage; for food preparation, the serving of meals, dishwashing, laundering, and housecleaning, with their related needs, for the storage of supplies and equipment and the disposal of wastes; for children's play, and for adult or adolescent hobbies; for personal hygiene, with particular reference to the problems of baby care and laundering for infants; and for the storage of miscellaneous household goods such as play-things, luggage, card tables, and sports equipment.

Some of these needs can best be served outside the dwelling unit itself, by facilities which will meet the requirements of many families on a staggered schedule. Club or assembly-rooms, which have been found vital in many housing developments, will provide for certain kinds of family entertainment and for occasional ceremonies such as weddings, anniversary or religious observances, and the like. They may also provide the needed opportunity for adolescent youth to meet persons of the opposite sex under wholesome conditions and without the expense of movie-going or other commercial recreation. The provision of communal laundry rooms, and of space which may be equipped by the residents themselves for nurseries or workshops, may make it possible to obtain cooperatively certain equipment or services which no individual family could afford.

In at least one recent housing project the problem of accommodating over-night guests has been met by reserving a special dwelling unit for their use. It should be possible in large-scale housing developments not only to experiment further with this principle of peak-load dormitory facilities but to extend it to cover the needs of persons quarantined during sickness.

Use-overcrowding may result, even in the well-planned dwelling, from inappropriate or badly placed furniture, especially when the new dwelling differs so markedly in plan from the old that customary patterns of living do not exploit the new opportunities. In such cases an important contribution to family life can be made by the housing management through simple suggestions as to desirable furniture arrangement or even, as has been done in certain projects, by giving help in the procurement of furniture appropriate to the new dwelling.

3. See footnote 1.

The continuance of the family in the community of its choice will be greatly fostered by the provision in every housing project of living units sufficiently varied in size to provide accommodations during the whole cycle of family development, from the phase of child rearing and gradually increasing family size, on to the period when parents whose grown children have set up their own homes will normally live by themselves. Related problems which must be solved by the planner are those of the non-typical household, such as the group of employed adults unrelated to one another and possibly desiring more than normal privacy, or the normal family plus grandparents or with an invalid member —in which cases unusual quiet or special access to the sun may be required. It is obvious that no advance provision can be made for each of these contingencies exactly as it will occur; the plea, however, can be made that the designers of housing visualize as fully as they can the varied uses of family life to which their buildings will be put, and that they provide all reasonable variety in plan arrangements. The housing needs of a population are not met by devising standard 3 and 4 and 6 room unit plans and repeating them endlessly without variation simply because they are efficient users of space and have an economical relation to plumbing stacks and stairs.

In this connection it is worthy of note that a responsible group of housing managers have recently cited as their greatest difficulty that of reconciling the living units they have to offer with the living needs of the families who apply to them for space. The conclusion seems warranted that these fundamental needs of family life have been seriously neglected in much recent American housing.

Principle 11. Provision of opportunities for normal community life

a. Specific Requirements. In order to promote the psychological and social values which result from participation in normal community life, the home should be located in a community which contains or has easy access to the basic institutions of culture and commerce, and from which the major centers of employment can be reached without undue expense or loss of time and energy in travel.

Among the community facilities which should be made conveniently accessible to the home, the most important are: schools, churches, facilities for necessary local shopping and entertainment, libraries, and medical service. (Facilities for physical recreation have been discussed above.

A vital community life should be fostered in housing developments by supplying, as a part of any new physical plant, the basic neighborhood facilities which are lacking, and by management policies which will encourage spontaneous community organization.

b. Methods of Attainment. This principle involves town and community planning and housing management as well as housing design in its narrower sense. It is, however, directly related to the choice of sites for housing projects and the plans for their subsequent development.

The school and the work place are vital elements in the community background of the home; they should be within reach without undue expenditure of time, energy, or money. Location of the school beyond a walking distance for the child may restrict his participation in normal and desirable extracurricular activities. If adults be required to spend an excessive amount of time daily in going to and from work, they may be subjected to considerable nervous and physical strain, and the time and energy available for recreation or participation in neighborhood activities will be materially curtailed. Suitability of location is obviously related to transportation facilities and to the family carfare budget, so that no definite standards can be set; yet the point is often of controlling importance in the selection of sites for housing development.

The provision, as an integral part of new housing developments, of community workshops and of health centers or clinics which function under the existing local public health service appears to offer sound possibilities which have been little explored.

Although the attitudes of local governments and housing management toward the autonomous community life of housing projects should be sympathetic, great care should be taken to avoid freezing the lines of social cleavage that may so easily form around the project dwellers as a

privileged group in the community. Management authorities should be alert both to encourage natural neighborhood groupings and to take advantage of normal social services existing in the area.

It should be noted that many recent housing projects not only meet the basic needs cited above but provide important opportunities for economic cooperation and a sense of community responsibility far greater than is ordinarily attained in either urban or rural life. It seems possible that in this regard our housing program is making a substantial contribution to the most vital of all American political needs —the consciousness of and participation in the common tasks of community living.

Principle 12. Provision of facilities which make possible the performance of the tasks of the household without undue physical and mental fatigue

a. Specific Requirements. This principle involves avoidance of both physiological and psychological factors contributing to fatigue. The home is not merely a dwelling; for the housewife it is a work place as well. Recent studies show that some 60 person-hours of homemaking activities per week are required in the average home. The principles of sound industrial hygiene demand directness of circulation and good facilities for storage, cooking, laundering, and refuse disposal. Cleansing, which is also important in this connection, is discussed under Principle 13.

b. Methods of Attainment. In order to minimize fatigue from needless walking in the performance of household tasks, halls and doors should be so located that internal circulation be direct and access to outside entrances (both front and rear) convenient, especially from the kitchen. Door swings should be so arranged as to minimize interference with other doors, with furniture placement, or with circulation. Easy access to the ground is important to the housewife when she has packages to carry in, the baby to be sunned, or washing to be hung out. Walk-up apartments should therefore be limited in height to 3 stories.

So far as storage is concerned, home economics authorities emphasize the need for a closet or wardrobe at least 22 inches deep and 3 feet or more in width for each bedroom, cupboard space in the kitchen (protected against dust and flies), provision for storing brooms and ironing-boards, and additional general storage space for miscellaneous objects other than personal clothing and kitchen equipment. In multiple-dwellings a common storage space for baby carriages and bicycles should be provided, accessible by a ramp if not at grade.

From the standpoint of equipment, the kitchen should be provided with a suitable range. In urban areas a gas or electric range is desirable, which must meet the standards of safety discussed in a succeeding section.

The best height of any work surface depends upon the size and the proportions of the worker and upon the nature of the task. When the height of the work surface is not suited to the worker or to the job, the wrong muscles are used, and this, if continued, may result in sagging abdominal muscles and organs, spinal curvatures, round shoulders, and crowded lungs, through the stooped position into which the worker is forced when the work surface is too low or through the unnatural lifting of the shoulders necessitated by a surface which is too high.

In a recent study of the heights preferred for different kitchen tasks by 562 American women, it was found that 82 percent of them could use, without being conscious of strain, a dishwashing height of 32 1/2 inches, and 92 percent a rolling height of 33 1/2 inches. The height preferred for beating was in most cases 2 inches less than that for rolling. While preferred heights are not always the best heights as measured by the output of work, studies of output of kitchen work have not been made, or at any rate have not been reported. For the present, then, it would seem that dwellings which are to be rented should have work surfaces of the heights indicated. This means a sink with the bottom set 32 1/2 inches above the floor and a work surface to serve for beating and mixing set 31 1/2 inches above the floor. The rolling surface may be a board built up at the edges to a thickness of 2 inches, which when laid on the work surface will be the right height for rolling.

When the sink is set at the correct height, the surface level with its rim is too high for mixing and beating. When a lower surface for mixing and beating cannot be provided, the sink may

be set at such a height that the surface level with its top is 31 1/2 inches above the floor. This of course makes the bottom of the sink too low for comfort in washing dishes, but the dishpan may be set upon the mixing surface while dishwashing is in progress.

From the studies cited above, it seems clear that the best height for the bottom of the sink is 32 1/2 inches, with a drainboard whose height will be determined by the level of the top of the sink, provided that other built-in work surfaces not more than 32 inches from the floor be available.

There is no objection to a double drainboard unless space be limited so that the double drainboard leaves too little room for a counter or a movable table provided by the tenant for mixing and beating. When the amount of space available is restricted, the range top or the table or counter for mixing and beating may be placed at the right of the sink and serve as a stacking surface for solid dishes.

The modern streamlined kitchen with a counter into which a sink is set occupying all the wall space not taken up by doors, range, and refrigerator does not provide the best conditions for work but is preferred by many on esthetic grounds.

Where laundering is done on the premises, a laundry tub and available drying facilities are essential. In multiple-dwellings, common laundries should be provided if it be probable that they will be used by the prospective occupants.

The convenient disposal of garbage and refuse is important for many reasons, including control of flies, rats, and other vermin which may spread disease, and avoidance of fire hazards, as well as for the maintenance of self-respect. In congested areas, a sanitary nonabsorptive receptacle for garbage is an essential part of house equipment, and in multiple dwellings special chutes discharging into incinerators have been found desirable. The best type of outside garbage receptacle is one that is set below the ground surface and protected from access of animals. A separate receptable for ashes and rubbish should be provided where necessary, protected against dissemination of its contents by the wind.

Principle 13. Provision of facilities for maintenance of cleanliness of the dwelling and of the person

a. Specific Requirements. Cleanliness of the dwelling depends in part on such construction as will facilitate cleansing; both dwelling cleanliness and personal cleanliness demand an ample supply of water (20 gallons per day is a minimum for household use), with facilities for heating water. The ends in view are justified in part by the role of clean hands in preventing the spread of germ diseases, but on an even wider base they may be considered essential to self-respect from a psychological standpoint.

b. Methods of Attainment. To facilitate household cleansing, interior surfaces should be as nearly impervious, and joints between surfaces as tight as is reasonably practical. Design should minimize dust-catching angles and pockets. Surfaces should be readily washable.

A safe water supply, adequate in quantity and under pressure, should be available within the dwelling. Where water has to be brought in by hand it will not be used in amounts necessary for cleanliness. Anything short of a pressure supply is a substandard compromise.

A bathtub or shower should be provided for each family where pressure water is available, in addition to a wash basin.

Finally, at least a minimum supply of hot water is an essential of sanitary decency. This may be provided in the very low-cost rural home by heating water on the stove, but a hot-water heater is a basic element in really satisfactory housing.

Principle 14. Provision of possibilities for esthetic satisfaction in the home and its surroundings.

a. Specific Requirements. It is obvious that matters of taste cannot be crystallized in

quantitative terms, but the desire for beauty is a fundamental urge whose satisfaction is essential to healthy living in the full sense of the term.

b. Methods of Attainment. The attainment of this end is dependent not on ingenuity in decoration or ornamentation, but on fundamental design and grouping of buildings in relation to the site and to each other, with due reference to the fact that variety is no less important than harmony.

Above all else it is essential that the buildings be placed and massed so as to give a sense of spacious openness and to conserve existing features of natural beauty. Simple landscape treatment, designed for low maintenance costs, can meet this requirement with no unreasonable burden on the rental scale.

Exterior beauty of buildings is best attained by rational design, simple harmonious masses, fresh colors, interesting wall-textures, well studied placement of windows in relation to their function —devices all of which depend more on skill than on expense —rather than by surface ornament, which is generally aimless, costly, and superfluous, and a confession of esthetic bankruptcy on the part of the designer.

Interiorly, the need is for harmonious settings for family life, with as much freedom as possible for esthetic self-expression. Among the means available to the skillful designer are well proportioned floor and wall spaces, windows and doors so placed as to present attractive vistas, and appropriate color schemes. Although meaningless ornaments and mouldings are best omitted reasonable provision should be made for hanging pictures and draperies. The dwelling as provided by the designer should not be regarded as a finished or static thing, but rather as a flexible background for living.

Principle 15. Concordance with prevailing social standards of the local community.

a. Specific Requirements. Requirements here are obviously purely relative. It should, however, be pointed out that the sense of inferiority developed in a home notably below the standard of friends and neighbors may, and often does, produce emotional reactions, particularly in children, which are fundamentally incompatible with mental health. The public has developed a keen sensitiveness to the dangers of communicable disease, but still fails to realize the importance of emotional hazards. Under modern conditions of American living, a sense of inferiority due to living in a substandard home may often be a more serious health menance than any insanitary condition associated with housing.

b. Methods of Attainment. These again are relative and cannot be stated in any general terms. It is important that housing plans should take into account local social and racial standards which may profoundly modify the applications of the principle under discussion.

Social standards of a given area should be protected by proper zoning ordinances.

Control of the environment in the interest of community well-being has long been practiced in the protection of communal water supplies and the prevention of communicable disease. The modern community must extend this control to cover sources of social contagion as well. Unregulated saloons, pool-rooms, commercial dance halls, etc., may have mental hygiene effects, particularly on adolescent youth, quite as serious as the analogous physical effects of failure to control disease. Such potential sources of social contagion should be rigorously excluded from the modern housing development, and in so far as possible from its vicinity.

C. Protection Against Contagion

Principle 16. Provision of a water supply of safe sanitary quality, available to the dwelling.

a. Specific Requirements. The water supply system should be so located, constructed, and operated that the water supply will not be a means of conveying disease; and the water should be devoid of objectionable chemical and physical characteristics. In some localities, it may be impossible to obtain water that meets all of these requirements, but in any case only a water that is safe from a public health point of view should be used. The United States Treasury Department standard[4] for interstate-carrier water supplies may be used in determining safety. The

[4]Refers to U. S. Public Health Service Standards while the latter was still an agency in the Treasury Department. The latest standards were published in 1962.

United States Public Health Service has prepared a water supply code which should serve as an excellent guide in water supply sanitation.

b. Methods of Attainment. The ideal is, of course, a communal supply which is approved by health authorities. The availability of such a supply should be an important factor in selecting sites for housing projects.

Where individual supplies are the only ones obtainable, a properly protected spring or well is ordinarily the best solution of the problem. Surface supplies are usually not practical for converting into safe individual household supplies. The conditions necessary to insure a sanitary individual supply are outlined in the United States Public Health Service Publication No. 24 (revised 1962) titled Manual of Individual Water Supply Systems and is described in Chapter XI of this Book under Individual Water Supply Systems.

Principle 17. Protection of the Water supply system against pollution within the dwelling.

a. Specific Requirements. This principle requires construction of house plumbing in such a way that the water cannot be contaminated by cross-connections, by siphonage from bowls, tubs, or toilets, or by drip into water reservoirs.

b. Methods of Attainment. Direct cross-connections or contamination of water reservoirs can be avoided by proper initial construction and by routine inspection of large installations by health departments to check on alterations. To avoid one common and possibly serious source of contamination —back-siphonage of polluted water into the supply —all fixture inlets which are directly connected to the supply system should be at a sufficient distance above the possible water level attained in the fixture itself to prevent contact. Numerous types of lavatories, drinking fountains, and other fixtures now in common use (and even some of those installed in recent public housing projects) violate this principle, although safe equipment be on the market.

There are available devices for the protection of existing fixtures which, when properly installed, afford a considerable degree of protection. Many such fixtures may be protected with very little labor or expense. All new plumbing installations, whether in new or old buildings, should be free from defects of all kinds which may permit water contamination to occur.

Suggestions for meeting the above conditions are given in the report of the Joint Committee on Plumbing of the Conference of State Sanitary Engineers and the American Public Health Association, published in the 1938-1939 Year Book of the American Public Health Association.

Principle 18. Provision of toilet facilities of such a character as to minimize the danger of transmitting disease.

a. Specific Requirements. This principle involves, on the one hand, prevention of spread of infection by flies or other insects and, on the other, reduction of the likelihood of transmitting intestinal or venereal diseases by contact.

b. Methods of Attainment. The ideal method of controlling access of insects to fecal discharges is the water carriage system of sewerage, and housing projects should —so far as is possible —be located where such facilities are available. For the isolated home where water carriage is impossible, a sanitary privy so constructed as to protect fecal deposits from access of flies, and so located as not to endanger a water supply, is obviously a minimum essential. The type of privy recommended by the United States Public Health Service may be used where this method of disposal is unavoidable.

A separate toilet for each family would seem to be essential to insure responsibility for cleanliness as well as to promote decency.

Toilets should be located at a sufficient elevation above the sewer level to avoid back flooding.

From the standpoint of avoiding venereal disease transmission, the toilet seat should be of an open-front type.

To avoid dangers of infection from contact with fecal matter, the walls and floor of the toilet

compartment should be of material which is as nearly impervious as possible. Good lighting of the compartment is essential, since visibility is a major factor in stimulating habits of personal cleanliness. Artificial lighting alone is unsatisfactory on account of maintenance problems; a window opening to the outer air should be considered a minimum essential for all new construction.

If the toilet compartment has a window opening the outer air, no special provision for ventilation is necessary. Furthermore, many plumbing codes require unnecessary construction costs. The Recommended Minimum Requirements for Plumbing published by the National Bureau of Standards should be used for the revision of obsolete plumbing codes.

Principle 19. Protection against sewage contamination of the interior surfaces of the dwelling.

a. Specific Requirements. This principle involves tightness of the house drainage system and construction of the main house drain and the external sewerage system so as to avoid back-flooding.

b. Methods of Attainment. Leaks of sewage on cellar floors, work surfaces, or elsewhere can be avoided by tightness of construction. To prevent the backing up of sewage into the dwelling, care should be exercised in selecting sites where adequate sewage disposal facilities are, or can be provided. Preference should be given to locations where separate systems of sanitary and storm sewers are available and to locations where ample fall can be obtained between the basement floor of the dwelling and the street sewer. Where such separate systems are in use, storm water from the roof and surface drainage should be conducted to the storm water sewer, and only domestic sewage and basement drainage allowed to enter the house sewer. Where necessary, the hazard of back-flooding the basement may be minimized by (1) installing an automatic back-water valve and a gate valve on the branch drain to which basement plumbing fixtures are connected, or (2) connecting the outlets of basement plumbing to a sump equipped with a suitable automatic electrically-driven pump or compressed-air ejector which is arranged to discharge into the building sewer, stack, or street sewer. Water-operated sump pumps or ejectors should not be used, since they may involve a very serious cross-connection between the sewer and water supply piping.

In the case of an isolated dwelling which is provided with an individual sewage disposal system, only domestic sewage and basement drainage should enter the system.

Principle 20. Avoidance of insanitary conditions in the vicinity of the dwelling

a. Specific Requirements. Where a local sewage disposal plant is maintained, it must be so designed and operated as to avoid exposure of sewage which will permit transmission of disease by contact, by flies, or by pollution of wells; and the neighborhood must be kept free from accumulations of refuse which will afford food or harborage of flies or rats, and from standing water in which mosquitoes may breed.

b. Methods of Attainment. Where a local sewage disposal system is used, certain principles concerning the location and construction of such installations should be observed (such as location and depth of sewer; pipe sizes, materials, and jointing; and location, capacity, and covering of tanks.) State health departments usually provide specifications in regard to these points. Minimum standards for the location and design of sewage disposal systems for isolated dwellings where a settling tank and soil absorption system is used should be in accordance to the recommendations in the Public Health Service Manual on Septic Tank Practice, Publication No. 526, 1963. The possibility of contaminating wells through the soil should be avoided in locating privies and sewage disposal systems. (Particularly in clay, or limestone regions, possibilities of safe sewage disposal for the population involved should be considered in choosing a housing site.)

Accumulations of organic refuse which will breed flies should be avoided by provision of facilities for the removal and disposal of such refuse. Accumulations of rubbish, piles of lumber, etc. may provide harborage for rats and should not be permitted.

Stagnant water should, where possible, be removed by drainage or filling; bodies of water

which cannot be removed and which are of a character to permit mosquito breeding should be treated by appropriate anti-larval methods.

Principle 21. Exclusion from the dwelling of vermin which may play a part in the transmission of disease.

a. Specific Requirements. This principle is concerned primarily with protection against mosquitoes, flies, and rats.

b. Methods of Attainment. Where mosquitoes and flies are present, all doors, windows, and other openings should be screened with No. 16 wire mesh. Screen doors should always open outward and should be self-closing. It is desirable to screen an entire window rather than only a part of it.

Where the rat problem is appreciable, care should be taken to close effectively all openings through foundations and floors, as, for instance, those around pipes and cracked walls. Such openings should be closed with metal sheeting or concrete or other suitable rat-proofing material, such as asbestos board. Basement windows should be covered with strong, durable screening, such as standard 8-mesh galvanized hardware cloth. Ventilators and sewer openings should be provided with gratings. Exterior doors should be self-closing. The building foundation should be of concrete or masonry (or otherwise rendered rat-proof) and should extend (aside from frost or structural load considerations) from a point at least 2 feet below ground to a point at least 2 feet above ground. In case the floor be closer to the ground than 2 feet, the space in the walls between the studding should be filled with concrete, or other material indestructible by rats, up to a point 2 feet above ground level.

Where the population to be housed is likely to be infested with vermin, provision may have to be made for fumigating clothing and furniture before occupancy is permitted.

Principle 22. Provision of facilities for keeping milk and food undecomposed

a. Specific Requirements. Various bacteria which cause food poisoning may propagate in foods which are not adequately cooled. Every home should have facilities for holding perishable foods at 50° F. or below.

b. Methods of Attainment. Either a mechanical refrigerator or a suitably constructed ice refrigerator should be considered an essential element in home equipment. Even in northern climates this will be necessary in summer. The amount of refrigerated food storage space desirable for urban homes depends upon the food habits of the family and upon the marketing practices of the housewife. A minimum of 4 cubic feet per family will suffice, however, for the essential needs of most urban households.

Drains from ice refrigerators should be completely disconnected from sewers and other waste lines; there should be an air gap of not less than 1 inch, measured vertically, between the ice refrigerator drain and the rim of the fixture into which it discharges.

Principle 23. Provision of sufficient space in sleeping-rooms to minimize the danger of contact infection.

a. Specific Requirements. Experience in barracks and institutions has shown that a distance of less than 6 feet between the centers of adjoining cots or a space of less than 50 square feet per bed may lead to the spread of communicable diseases by dissemination of mouth spray from an infected occupant. The distance of 6 feet between the centers of adjacent army cots would imply at least a 3 foot space between the beds themselves, which is the essential point.

b. Methods of Attainment. To make it possible to meet the requirements above, the sleeping-room should therefore have approximately 50 square feet of floor space per occupant. This amount of space will also be generally required for placement of the customary bedroom furniture. With ceiling heights ranging from about 7 feet 8 inches to 8 feet, such sleeping-rooms will check satisfactorily with the requirement of 400 cubic feet of space per occupant specified in Principle 3. [5]

5. See footnote 1.

Double-deck beds, sometimes advocated as a space-saving device, are undesirable as favoring mouth spray infection.

D. Protection Against Accidents[6]

Principle 24. Erection of the dwelling with such materials and methods of construction as to minimize danger of accidents due to collapse of any part of the structure.

a. Specific Requirements. These are being studied by the Building Code Correlating Committee of the American Standards Association, whose program includes standards for excavations and foundations, masonry work, iron and steel work, and structural loads.

b. Methods of Attainment. The ways in which such safety requirements can be translated into practice are obviously too complex to be cited here.

In view of current interest in the problem, a word may be said as to the structural menace of termite infestation. In zones where such infestation is serious, special provision should be made for termite control by constructing foundations of impenetrable concrete or masonry, and by removing stumps, chips, and litter from beneath the house. Adequate ventilation should be provided for the space beneath the house; vents should be screened; the clearance between the ground and woodwork should be at least 6 inches for the outside foundation and 18 inches inside; and for the most effective protection, termite shields of copper or other durable metal should cap the foundation wall. For complete protection, these shields should be continuous and extend entirely across the foundation wall, should project 2 inches or more on either side, and should be bent down at an angle of 45°. All posts, piers, pipes, and other structural members in contact with the ground should be shielded with projecting caps or collars. Surfaces that are difficult to inspect should be given the most thorough protection.

Principle 25. Control of conditions likely to cause fires or to promote their spread.

a. Specific Requirements. All that can be insisted on —from the standpoint of protecting the lives of occupants —is that dwellings shall be so constructed and equipped as to minimize the probability of starting fires, and that the spread of fires shall be sufficiently retarded to permit the escape of occupants. Local building codes may require that dwellings shall not collapse for a period of several hours under fire conditions so extreme as to preclude the survival of any occupant. Such requirements, which add to the cost of building, must find their justification on other grounds than those of human safety.

b. Methods of Attainment. Potential sources of fire within the dwelling exist in electric installations, stoves and furnaces and their smoke-pipes, and chimneys. Prevention of electrical fires calls for such details of construction as will control danger of crosses and the avoidance of exposed wiring subject to short-circuiting through wear. These factors are adequately dealt with by the usual local electrical codes. Stoves or furnaces should be mounted clear of combustible walls and floors, and if located near woodwork, should be insulated from it by adequate air space and by mats or screens of non-combustible material. Smoke-pipes should be securely supported, well separated from woodwork or other inflammable materials, and kept clean. Where such a pipe must pass through a combustible partition, a ventilated thimble should be used to provide an air space around the pipe. Stove-pipe openings in chimneys should be covered when not in use.

Chimneys should be so constructed and supported as to avoid danger of over-heating adjacent combustible elements. Masonry chimneys should be lined with fire-clay tile, with joints staggered in relation to masonry courses. Wood beams, joists, or partition members should be placed at least 2 inches away from chimneys, with the intervening space mortar-filled or otherwise effectively insulated.

In order to prevent the spread of fire originating within the structure, safe practice demands that in multiple dwellings (regardless of height) the stairways be enclosed by fire-resistive materials, and that in all such dwellings over 2 stories in height the following elements be of fire-resistive construction: exterior walls, roofs, first-tier beams, partitions between apartments and between stair halls and apartments, and all shafts. ("Fire-resistive" materials are meant to include those which upon test show that they will resist fire or delay its spread for a sufficient

6. The importance of this problem is indicated by the fact that in 1965 home accidents in the United States caused 24,100 fatalities as compared with 25,900 fatalities caused by tuberculosis, syphilis, meningococcal meningitis, acute poliomyelitis, infectious hepatitis, influenza, bronchitis, and other infectious and parasitic diseases.

time to permit the escape of occupants.) It is hardly less desirable that all floors and floor joists also be fire-resistive. All multiple dwellings exceeding 4 stories in height should have non-combustible floors and floor joists, and all those exceeding 6 stories in height should be non-combustible throughout.

For single-family dwellings of low cost, such fire-resistive construction may not be feasible, but fire hazards should be restricted through care in the installation of stoves, chimneys, and electric wiring as described above, through fire-stopping, and through reasonable precautions in the construction and finishing of roofs and walls.

Where framing with combustible members involves hollow wall spaces, the spread of fire can be retarded by closure of these spaces with fire-stops at the floor, wall, and roof lines. Well-fitted boards can serve as temporary checks, but better results will be obtained by filling the voids with non-combustible materials for a distance of 4 inches or more above the fire-stops.

Fires are commonly spread from building to building by brands or radiant heat. Most of the non-combustible types of roofing have sufficient insulating value to prevent ignition of the boards supporting them by either of these means. The protection afforded by metal roofings can be increased by placing asbestos felt between the roofing and the boards. Wood shingles should not be used on account of their poor resistance to brands; once afire, they may themselves give off flying brands and set fire to neighboring structures. Weathered wood shingles are particularly subject to ignition by brands.

Among the common exterior wall materials, the range in fire resistance begins with board finish and runs in order through phenol plywood, stucco on wood lath, stucco on metal lath, and masonry veneer over wood frame, to load-bearing masonry walls. Well-maintained paint coatings will slightly increase the fire resistance of a wood surface to exterior fire sources.

It should be a routine requirement that inflammable buildings be spaced far enough apart to prevent the spread of fire by radiant heat.

Fire-fighting provisions which are usually necessary include reasonable accessibility of each dwelling to fire-fighting vehicles and an adequate water supply for fire apparatus. The provision of chemical fire-extinguishers may be justified in the halls of multiple dwellings.

Principle 26. Provision of adequate facilities for escape in case of fire

a. Specific Requirements. In every living unit, the existence of exits which will not be cut off in case of fire should be regarded as a minimum essential; and these exits should be of such a nature that they can safely be used by women and children and at night.

b. Methods of Attainment. Multiple dwellings should be provided with at least two means of exit from each living unit. For reasons of economy in construction, exception may reasonably be made in the case of multiple dwellings of 4 stories or less which conform to Methods of Attainment under Principle 25 and are provided with stairways in separate fire-resistive enclosures having self-closing doors at each floor; compromises may also perhaps be made in certain cases of two-story combustible buildings.

In multiple dwellings, the doors of public exits should open outward.

Where local ordinances require outside fire-escapes, these should be constructed in accordance with the Building Exits Code of the American Standards Association. It is vital that fire-escapes should terminate on solid level ground or pavement in locations from which egress is unencumbered.

It is important to note that many types of drop ladders now permitted by local codes are so heavy and difficult to manipulate (particularly when rusted or heavily painted) that only a trained athlete can be expected to use them. The danger from these devices to a woman or child on an icy night is very serious.

Principle 27. Protection against danger of electrical shocks and burns

a. Specific Requirements. The requirements as to structural installations (aside from fire hazards) are two: (1) Live conductors and live parts of electric equipment should not be exposed to contact. (2) Exposed metal enclosures should be grounded so as not to become alive from failure of insulation. Portable appliances and pendent fixtures should be so placed that a person will not simultaneously come in contact with electric fixtures and with plumbing fixtures or other grounded metal.

b. Methods of Attainment. In bathrooms, laundries, kitchens, or other spaces where the hands are likely to become wet, electric lights should be controlled by wall switches or pull chains containing insulating links, and any lamp sockets within reach should have non-metallic shells. Convenience outlets in such spaces should be located so as to minimize the probability of touching plumbing fixtures while using electric appliances. Where it is necessary, because of limited space, to locate switch or convenience outlets within reach from plumbing fixtures, cover plates for such outlets should be non-metallic. In no case, however, should wall switches be located within reach of an occupant of a bathtub.

Convenience outlets should be located not in baseboards but high enough to be out of reach of creeping infants, which placement also brings them within more convenient access for the user. Any permanently installed electric heater should have a protective grating to prevent contact.

Principle 28. Protection against gas poisonings

a. Specific Requirements. The chief toxic substances likely to be associated with the dwelling are carbon monoxide from imperfect combustion in cooking or heating appliances, leaking gas from fixtures, and toxic gases from certain refrigerating devices. The control of such hazards is obviously essential.

b. Methods of Attainment. Any gas cooking-ovens and space heaters which involve the possibility of partial combustion must be provided with an adequate flue opening to the outer air. Chimneys, furnaces, and stove-pipes should be maintained in tight and clean condition, as should gas connections and gas heating appliances.

Where toxic gases are employed in multiple refrigerator installations, special attention should be paid to tight and durable jointing, and a warning gas should be added to odorless toxic refrigerants (in replacing routine leakage as well as in the original installation.) Rooms which contain gas cooking appliances or mechanical refrigerators should not be used for sleeping.

Precautions against carbon monoxide poisoning in a domestic garage are obviously essential, but ordinarily involve no special structural provisions.

Principle 29. Protection against falls and other mechanical injuries in the home.

a. Specific Requirements. Hazards of this type are too diverse to be catalogued, but it is clearly essential that stairs, windows, and balconies should be so constructed as to minimize danger of falls. In view of the many serious falls which occur in the bathtub, this problem should be kept in mind in planning the bathroom. Protection should be also given against injuries on outside steps and walks.

b. Methods of Attainment. A stairway should not be made too steep, and a proper proportion should be maintained between the dimensions of riser and tread. Satisfactory values are 7 to 7 1/2 inches for the riser and 10 inches for the tread. In any case, these values should meet the conditions that the sum of the tread and twice the riser equals 24 to 25 inches, and that the angle of slope is between 30° and 36°. Steps of a flight should be uniform in dimensions, as any irregularity may cause tripping.

It is essential to provide every flight of stairs with a handrail. Outdoor steps especially need rails in northern latitudes, because of ice.

Winding stairways too narrow for foothold at the rail side must be avoided, as they particularly invite falls. If a doorway be placed at the head of a flight of stairs, which practice has merit

from the standpoint of preventing the spread of fire, there should be a landing at least 30 inches wide on the stair side of the door. If this landing be omitted, the door should have a glazed window.

Low window sills (less than 30 inches from the floor) should be avoided, especially at stairway landings. If unavoidable, low windows may be provided with one or more cross-bars to prevent children from falling out. Built-in window screens have advantages, from the casualty prevention viewpoint.

Casement windows, if designed with sufficient clearance at the hinge to permit washing from the inside, will minimize dangers in window cleaning.

There should be railings or parapets around porches, balconies, accessible roofs, etc., high enough (at least 30 inches) to prevent falling off the edge. Such falls may cause serious accidents even when the distance is not more than 2 or 3 feet.

In bathrooms, especially where built-in tubs are installed below tiled walls, built-in handgrips should be provided, sufficiently in front of the bather's position to be within convenient reach.

In the North, sloping roofs (with a pitch of perhaps from 15^{o} to 55^{o}) which end over steps or walks should be equipped with snow guards to prevent masses of snow from sliding onto the head of the passerby.

Adequate lighting of exterior courts, walks, and particularly of steps, is an essential safety factor.

Principle 30. Protection of the neighborhood against the hazards of automobile traffic

a. Specific Requirements. Attainment of this ideal must obviously be relative, and no specific standards can be set.

b. Methods of Attainment. Traffic regulation is an essential element in modern community planning; and it is particularly important that traffic in the vicinity of dwellings should be so organized as to minimize danger to both motorists and pedestrians (particularly children.)

Residential streets should therefore be so planned as to discourage through traffic. It is often possible to do this in new housing communities by means of dead-end streets. Blind corners should be avoided by proper study of placement of both the buildings and shrubbery.

Pedestrian routes from all residential areas should be so planned that elementary schools, local shops, playgrounds, etc., may be easily reached without crossing any major traffic way except by the use of overpasses or underpasses.

Playgrounds should be effectively screened off from automobile ways.

In the 15 years since A Proposed Housing Ordinance was first published (1952), the science and art of the control of housing through administrative law has developed to the point where the original document is in need of revision. We have come a long way since the Housing Act of 1949 which gave the newly needed impetus toward the elimination of poor housing and the production of sound and decent housing which Dr. C.-E.A. Winslow's APHA housing committee set into motion in the 1930's. Taking into consideration the need to modify the technical, legal, and administrative provisions of "A Proposed Housing Ordinance," the Subcommittee on Housing Regulations and Standards, Program Area Committee on Housing and Health, APHA, (the successor to the Committee on the Hygiene of Housing) in collaboration with the Office of Urban Environmental Health Planning, National Center for Urban and Industrial Health, U.S.P.H.S., undertook the task of developing a revision of the original model housing code. The APHA-PHS Recommended Housing Maintenance and Occupancy Ordinance (1967) is the result.

A Proposed Housing Maintenance and Occupance Ordinance (Title and adopting language should conform to requirements of local law.)

Be it ordained by the (name of legislative body) of the (name of corporate unit), as follows:

Section I. General Provisions. The following general provision shall apply in the interpretation and enforcement of this ordinance:

1.01. Legislative Finding. It is hereby found that there exist and may in the future exist, within the (name of corporate unit) premises, dwellings, dwelling units, rooming units, or parts thereof, which by reason of their structure, equipment, sanitation, maintenance, use, or occupancy affect or are likely to affect adversely the public health, (including the physical, mental, and social well-being of persons and families), safety, and general welfare. To correct and prevent the existence of such adverse conditions, and to achieve and maintain such levels of residential environmental quality as will protect and promote public health, safety, and general welfare, it is further found that the establishment and enforcement of minimum housing standards are required.

1.02. Purposes. It is hereby declared that the purpose of this ordinance is to protect, preserve, and promote the physical and mental health and social well-being of the people, to prevent and control incidence of communicable diseases, to regulate privately and publicly owned dwellings for the purpose of maintaining adequate sanitation and public health, and to protect the safety of the people and to promote the general welfare by legislation which shall be applicable to all dwellings now in existence or hereafter constructed. It is hereby further declared that the purpose of this ordinance is to insure that the quality of housing is adequate for protection of public health, safety and general welfare, including: establishment of minimum standards for basic equipment and facilities for light, ventilation, and thermal conditions, for safety from fire and accidents, for the use and location and amount of space for human occupancy, and for an adequate level of maintenance; determination of the responsibilities of owners, operators and occupants of dwellings; and provision for the administration and enforcement thereof.

1.03. Title. This ordinance shall be known and may be cited as the Housing Maintenance and Occupancy Code of the (name of corporate unit).

Section II. The following definitions shall apply in the interpretation and enforcement of this ordinance:

2.01. Accessory Structure shall mean a detached structure located on or partially on any premise which is not used or not intended to be used for living or sleeping by human occupants.

2.02. Approved shall mean approved by the local or State authority having such administrative authority.

2.03. Appropriate Authority shall mean that person within the governmental structure of the corporate unit charged with the administration of the appropriate code.

2.04. Ashes shall mean the residue from the burning of combustible materials.

2.05. Chimney shall mean a vertical masonry shaft of reinforced concrete, or other approved noncombustible, heat resisting material enclosing one or more flues, for the purpose of removing products of combustion from solid, liquid or gas fuel.

2.06. Central Heating System shall mean a single system supplying heat to one or more dwelling unit(s) or more than one rooming unit.

2.07. Dormitory shall mean a room in any dwelling used for sleeping purposes by four (4) or more unrelated persons.

2.08. Dwelling shall mean any enclosed space which is wholly or partly used or intended to be used for living or sleeping by human occupants; provided that temporary housing as hereinafter defined shall not be regarded as a dwelling.

2.09. Dwelling Unit shall mean any room or group of rooms located within a dwelling and forming a single habitable unit with facilities which are used or intended to be used for living, sleeping, cooking, and eating.

2.10. Extermination shall mean the control and elimination of insects, rodents, or other pests by eliminating their harborage places; by removing or making inaccessible materials that may serve as their food; by poisoning, spraying, fumigating, trapping, or by any other recognized and legal pest elimination methods approved by the local or State authority having such administrative authority.

2.11. Family shall mean one adult person plus one or more persons who are legally related to said person and residing in the same dwelling unit with said person.

2.12. Flush Water Closet shall mean a toilet bowl flushed with water under pressure with a water sealed trap above the floor level. Such toilet bowls shall have a smooth, easily cleanable surface.

2.13. Garbage shall mean the animal and vegetable waste resulting from the handling, preparation, cooking, serving, and non-consumption of food.

2.14. Guest shall mean any person who shares a dwelling unit in a nonpermanent status for not more than 30 days.

2.15. Habitable Room shall mean a room or enclosed floor space used or intended to be used for living, sleeping, cooking, or eating purposes, excluding bathrooms, water closet compartments, laundries, furnace rooms, pantries, kitchenettes and utility rooms of less than 50 square feet, foyers, or communicating corridors, stairways, closets, storage spaces, and workshops, hobby and recreation areas in unsealed or uninsulated parts of structure below ground level or in attics.

2.16. Health Officer shall mean the legally designated health authority of the (name of corporate unit) or his authorized representative. (If the legally designated health authority has a title other than "Health Officer" the title of this authority should be substituted for "Health Officer" in this section and all other sections of this ordinance.)

2.17. Heated Water shall mean water heated to a temperature of not less than 120° F.

2.18. Household shall mean a family and/or one or more unrelated persons, who shares the same dwelling and uses some or all of its cooking and eating facilities, including servants and not more than two boarders.

2.19. Infestation shall mean the presence within or around a dwelling of any insects, rodents, or other pests.

2.20. Kitchen shall mean any room containing any or all of the following equipment; or area of a room within 3 feet of such equipment: sink and/or other device for dishwashing, stove or other device for cooking, refrigerator or other device for cool storage of food, cabinets and/or shelves for storage of equipment and utensils, and counter or table for food preparation.

2.21. Meaning of Certain Words. Whenever the words "dwelling," "dwelling unit," "rooming house," "rooming units," "premises," "structure" are used in the Ordinance they shall be construed as though they were followed by the words "or any part thereof". Words used in the singular include the plural, and the plural the singular, the masculine gender includes the feminine and the feminine the masculine.

2.22. Multiple Dwelling shall mean any dwelling containing more than two dwelling units and/or rooming units.

2.23. Occupant shall mean any person, over 1 year of age, living, sleeping, cooking, or eating in, or actually having possession of, a dwelling unit or a rooming unit; except that in dwelling units a guest will not be considered an occupant.

2.24. Operator shall mean any person who has charge, care, control, or management of a building, or part thereof, in which dwelling units or rooming units are let.

2.24a. Ordinary Summer Conditions shall mean a temperature 10° below the highest recorded temperature in the locality for the prior ten year period.

2.25. Ordinary Winter Conditions shall mean a temperature 15° F. above the lowest recorded temperature in the locality for the prior ten year period.

2.26. Owner shall mean any person who, alone or jointly or severally with others:

(a) shall have legal title to any dwelling or dwelling unit, with or without accompanying actual possession thereof, or

(b) shall have charge, care, or control of any dwelling or dwelling unit, as owner or agent of the owner, or an executor, administrator, trustee, or guardian of the estate of the owner. Any such person thus representing the actual owner shall be bound to comply with the provisions of this ordinance and of rules and regulations adopted pursuant thereto, to the same extent as if he were the owner.

2.27. Permissible Occupancy shall mean the maximum number of persons permitted to reside in a dwelling unit or rooming unit.

2.28. Person shall mean and include any individual, firm, corporation, association, or partnership.

2.29. Plumbing shall mean and include all of the following supplied facilities and equipment gas pipes, gas burning equipment, water pipes, garbage disposal units, waste pipes, water

closets, sinks, installed dishwashers, lavatories, bathtubs, shower baths, installed clothes washing machines, catch basins, drains, vents, and any other similar supplied fixtures, together with all connections to water, sewer, or gas lines.

2.30. Privacy shall mean the ability of a person or persons to carry out an activity commenced without interruption or interference, either by sight or sound, by unwanted persons.

2.31. Premises shall mean a platted lot or part thereof or unplatted lot or parcel of land or plot of land, either occupied or unoccupied by any dwelling or non-dwelling structure and includes any such building, accessory structure or other structure thereon.

2.32. Refuse shall mean all putrescible and nonputrescible solids (except body wastes) including garbage, rubbish, ashes and dead animals.

2.33. Rooming House shall mean any dwelling or that part of any dwelling containing one or more rooming units, and/or one or more dormitory rooms.

2.34. Rooming Unit shall mean any room or group of rooms forming a single habitable unit used or intended to be used for living and sleeping, but not for cooking purposes.

2.35. Rubbish shall mean nonputrescible solid wastes (excluding ashes) consisting of either:

(a) combustible wastes such as paper, cardboard, plastic containers, yard clippings, and wood; or

(b) noncombustible wastes such as tin cans, glass and crockery.

2.36. Safety shall mean the condition of being free from danger and hazards which may cause accidents or disease.

2.37. Space Heater shall mean a self-contained, heating appliance of either the circulating type or the radiant type and intended primarily to heat only one room.

2.38. Supplied shall mean paid for, furnished by, provided by, or under the control of the owner or operator.

2.39. Temporary Housing shall mean any tent, trailer, mobile home, or any other structure used for human shelter which is designed to be transportable and which is not attached to the ground, to another structure, or to any utility system on the same premises for more than thirty consecutive days.

Section III. Responsibilities of Owners and Occupants

3.01. No owner or other person shall occupy or let to another person any dwelling or dwelling unit unless it and the premises be clean, sanitary, fit for human occupancy, and comply with all applicable legal requirements of the State of _____ and the (name of corporate unit).

3.02. Every owner of a dwelling containing two or more dwelling units shall maintain in a clean and sanitary condition the shared or public areas of the dwelling and premises thereof.

3.03. Every occupant of a dwelling or dwelling unit shall maintain in a clean and sanitary condition that part or those parts of the dwelling, dwelling unit and premises thereof that he occupies and controls.

3.04. Every occupant of a dwelling or dwelling unit shall store and dispose of all his rubbish in a clean, sanitary and safe manner.

3.05. Every occupant of a dwelling or dwelling unit shall store and dispose of all his garbage and any other organic waste which might provide food for insects and/or rodents, in a clean, sanitary and safe manner, and if a container be used for storage pending collection, it shall be rodent proof, insect proof, and water tight.

3.06. Every owner of a dwelling containing 3 or more dwelling units shall supply facilities or containers for the sanitary and safe storage and/or disposal of rubbish and garbage. In the case of single or two family dwellings it shall be the responsibility of the occupant to furnish such facilities or containers.

3.07. The owner of a dwelling unit shall be responsible for providing and hanging all screens and double or storm doors and windows whenever the same are required under the provisions of this ordinance or any rule or regulation adopted pursuant thereto, except where there be a written agreement between the owner and occupant. In the absence of such an agreement, maintenance or replacement of screens, storm doors and windows, once installed in any one season become the responsibility of the occupant.

3.08. Every occupant of a dwelling containing a single dwelling unit shall be responsible for the extermination of insects, and/or rodents, on the premises; and every occupant of a dwelling unit in a dwelling containing more than one dwelling unit shall be responsible for such extermination whenever his dwelling unit is the only one infested. Notwithstanding, the foregoing provisions of this subsection, whenever infestation is caused by failure of the owner to

maintain a dwelling in a rodent proof or reasonable insect-proof condition, extermination shall be the responsibility of the owner. Whenever infestation exists in two or more of the dwelling units in any dwelling, or in the shared or public parts of any dwelling containing two or more dwelling units, extermination thereof shall be the responsibility of the owner.

3.09. Every occupant of a dwelling unit shall keep all plumbing fixtures therein in a clean, sanitary and operable condition and shall be responsible for the exercise of reasonable care in the proper use and operation thereof.

3.10. From (date) until (date) and from (time of day) to (time of day), in every dwelling unit and/or rooming unit when the control of the supplied heat is the responsibility of a person other than the occupant, a temperature of at least 68° F. shall be maintained in all habitable rooms, bathrooms and water closet compartments at a distance of 18 inches above the floor level.

Section IV. Minimum Standards for Basic Equipment and Facilities

No person shall occupy as owner, occupant or let to another for occupancy any dwelling or dwelling unit, for the purposes of living, sleeping, cooking or eating therein, which does not comply with the following requirements:

4.01. Every dwelling unit shall have a room or portion of a room in which food may be prepared and/or cooked, which shall have adequate circulation area, and which shall be equipped with the following:

4.01.01. A kitchen sink in good working condition and properly connected to a water supply system which is approved by the appropriate authority and which provides at all times an adequate amount of heated and unheated running water under pressure, and which is connected to a sewer system approved by the appropriate authority.

4.01.02. Cabinets and/or shelves for the storage of eating, drinking, and cooking equipment and utensils and of food that does not under ordinary summer conditions require refrigeration for safe keeping; and a counter or table for food preparation; said cabinets and/or shelves and counter or table shall be adequate for the permissible occupancy of the dwelling unit and shall be of sound construction furnished with surfaces that are easily cleanable and that will not impart any toxic or deleterious effect to food.

4.01.03. A stove, or similar device, for cooking food and a refrigerator, or similar device, for the safe storage of food at temperatures less than 50° F., but more than 32° F., under ordinary maximum summer conditions, which are properly installed with all necessary connections for safe, sanitary and efficient operation; provided that such stove, refrigerator, and/or similar devices need not be installed when a dwelling unit is not occupied and when the occupant is expected to provide same on occupancy, and that sufficient space and adequate connections for the safe and efficient installation and operation of said stove, refrigerator and/or similar devices be provided.

4.02. Within every dwelling unit there shall be a non-habitable room which affords privacy to a person within said room and which is equipped with a flush water closet in good working condition. Said flush water closet shall be connected to a water system that at all times provides an adequate amount of running water under pressure to cause the water closet to be operated properly and shall be connected to a sewer system which is approved by the appropriate authority.

4.03. Within every dwelling unit there shall be a lavatory sink. Said lavatory sink may be in the same room as the flushwater closet, or, if located in another room, the lavatory sink shall be located in close proximity to the door leading directly into the room in which said water closet is located. The lavatory sink shall be in good working condition and properly connected to a water supply system which is approved by the appropriate authority and which provides at all times an adequate amount of heated and unheated running water under pressure, and which is connected to a sewer system approved by the appropriate authority.

4.04. Within every dwelling unit there shall be a room which affords privacy to a person within said room and which is equipped with a bathtub or shower in good working condition. Said bathtub or shower may be in the same room as the flush water closet or in another room and shall be properly connected to a water supply system which is approved by the appropriate authority and which provides at all times an adequate amount of heated and unheated, water under pressure, and which is connected to a sewer system approved by the appropriate authority.

4.05. Every dwelling unit shall have one or more approved means of egress, with minimum head room of six feet six inches, leading to safe and open space at ground level and every

dwelling unit in a multiple dwelling shall have immediate access to two or more approved means of egress with minimum head room of six feet six inches, leading to safe and open space at ground level, as required by the laws of this State and this (name of corporate unit).

4.06. Structurally sound hand rails shall be provided on any steps containing five risers or more. If steps be not enclosed, hand rails and balusters spaced no more than 6" apart shall be provided. Porches and/or balconies located more than three feet higher than the adjacent area shall have structurally sound protective hand rails (30"-36" high) and if unenclosed the balusters spaced no less than 6" apart.

4.07. Each dwelling shall have a suitable facility for the safe storage of drugs and household poisons.

Section V. Minimum Standards for Light and Ventilation

No person shall occupy as owner, occupant or let to another for occupancy any dwelling or dwelling unit, for the purpose of living therein, which does not comply with the following requirements:

5.01. Every habitable room shall have at least one window or sky-light facing outdoors provided that if connected to a room or area used seasonally (e.g. porch) then adequate daylight must be possible thru this inter-connection. The minimum total window or sky-light area, measured between stops, for every habitable room shall be at least ten percent of the floor area of such room but if light-obstruction structures be located less than three feet from the window and extend to a level above that of the ceiling of the room, such window shall not be deemed to face directly to the outdoors and shall not be included as contributing to the required minimum total window area.

5.02. Every habitable room shall have at least one window or sky-light facing directly outdoors which can easily be opened, or such other device as will adequately ventilate the room provided that if connected to a room or area used seasonally then adequate ventilation must be possible through this inter-connection. The total of openable window or sky-light area in every habitable room shall be equal to at least 45 percent of the minimum window area size or minimum sky-light type window size, as required in subsection 5.01 of this ordinance, except where there be supplied some other device affording adequate ventilation and approved by the appropriate authority.

5.03. Every bathroom and water closet compartment, and non-habitable room used for food preparation, shall comply with the light and ventilation requirement for habitable rooms contained in subsections 5.01 and 5.02, except that no window or sky-light shall be required in such rooms if they be equipped with a ventilation system in working condition, which is approved by the appropriate authority.

5.04. Where there is usable electric service available from power lines which are not more than three hundred (300) feet away from a dwelling, every dwelling, every dwelling unit and all public and common areas shall be supplied with electric service, outlets, and fixtures which shall be properly installed, shall be maintained in good and safe working condition, and shall be connected to a source of electric power in a manner prescribed by the ordinances, rules and regulations of the (name of corporate unit). The capacity of such services and the number of outlets and fixtures shall be as follows:

5.04.01. Every habitable room shall have an electric service and outlets and/or fixtures capable of providing at least 3 watts per square foot of total floor area.

5.04.02. Every habitable room, and non-habitable room used for food preparation, shall have at least one (1) floor- or wall-type electric convenience outlet for each sixty (60) square feet or fraction thereof of total floor area, and in no case less than two (2) such outlets.

5.04.03. Every water closet compartment, bathroom, and kitchen or kitchenette, laundry room, furnace room, and public hall shall contain at least one supplied ceiling or wall-type electric light fixture.

5.04.04. Convenient switches or equivalent devices for turning on one light in each room or passageway shall be located so as to permit the area ahead to be lighted.

5.05. Every public hall and stairway in every multiple dwelling shall be adequately lighted by natural or electric light at all times, so as to provide in all parts thereof at least 6 foot-candles of light at the tread or floor level. Every public hall and stairway in structures containing not more than two dwelling units may be supplied with conveniently located light switches controlling an adequate lighting system which may be turned on when needed, instead of full-time lighting.

Section VI. Minimum Thermal Standards

No person shall occupy as owner, occupant or let to another for occupancy any dwelling or dwelling unit, for the purpose of living therein, which does not comply with the following requirements:

6.01. Every dwelling shall have heating facilities which are properly installed, and are maintained in safe and good working condition, and are capable of safely and adequately heating all habitable rooms, bathrooms, and water closet compartments in every dwelling unit located therein to a temperature of at least 68° F. at a distance of 18 inches above floor level under ordinary winter conditions.

6.02. No owner or occupant shall install, operate or use an unvented space heater employing a flame.

Section VII. General Requirements Relating to the Safe and Sanitary Maintenance of Parts of Dwellings and Dwelling Units

No person shall occupy as owner, occupant or let to another for occupancy any dwelling or dwelling unit, for the purpose of living therein, which does not comply with the following requirements:

7.01. Every foundation, roof and exterior wall, door, sky-light and window shall be reasonably weather-tight, water-tight, and damp-free, and shall be kept in sound condition and good repair. Floors, interior walls and ceilings shall be sound and in good repair. All exterior wood surfaces, other than decay resistant woods, shall be protected from the elements and decay by paint or other protective covering or treatment using non-toxic materials where readily accessible to children. Walls shall be capable of affording privacy for the occupants. Every premises shall be graded, drained, free of standing water, and maintained in a clean, sanitary and safe condition.

7.02. Every window, exterior door and basement hatchway or similar devices, shall be kept rodent-proof and reasonably watertight and weathertight, and shall be kept in working condition and good repair.

7.02.01. During that portion of the year when there is a need for protection against mosquitoes, flies and other flying insects, every door opening directly from a dwelling unit to outside space shall have supplied properly fitting screens having at least 16 mesh and self-closing device; and every window or other device with openings to outdoor space, used or intended to be used for ventilation, shall likewise be supplied with screens: except that such screens shall not be required during such period (a) in rooms deemed by the Health Officer to be located high enough in the upper stories of a building as to be free from such insects, (b) in rooms located in areas of this (name of corporate unit) which are deemed by the Health Officer to have so few insects as to render screens unnecessary.

7.02.02. Every window located at or near ground level used or intended to be used for ventilation, and every other opening located at or near ground level which might provide an entry for rodents, shall be supplied with adequate screen or such other devices as will effectively prevent their entrance.

7.03. Every dwelling, multiple dwelling, rooming house or accessory structure and the premises on which located shall be maintained so as to prevent and eliminate rodent harborage.

7.04. All fences provided by the owner or agent on the premises and/or all fences erected or caused to be erected by an occupant shall be constructed of manufactured metal fencing material, wood, masonry, or other inert material. Such fences shall be maintained in good condition, uniform in height throughout, and any wood materials shall be protected against decay by use of paint or other preservative. Such fences shall be maintained in good repair. The permissible height and other characteristics of all fences shall conform to the appropriate statutes, ordinances, and regulations of this (name of corporate unit) and State of _____. Wherever any egress from the dwelling opens into the fenced area, there shall be a means of egress from the premises to any public way adjacent thereto.

7.05. Accessory structures present or provided by the owner, agent, or tenant occupant on the premises of a dwelling shall be structurally sound, be designed to prevent rodent harborage, and be maintained in good repair and free of vermin by the owner, agent, or occupant, or such structures shall be removed from the premises. The exterior of such structures shall be made weather resistant through the use of decay-resistant materials or the use of paint or other preservatives.

7.06. Every foundation, roof, floor, exterior and interior wall, ceiling, inside and outside stair, every porch, and every appurtenance thereto, shall be safe to use and capable of supporting the loads that normal use may cause to be placed thereon; and shall be kept in sound condition and good repair. Every inside and outside stair or step shall have uniform risers

and treads.

7.07. Every plumbing fixture and water and waste pipe shall be properly installed and maintained in good sanitary working condition.

7.08. Every water closet compartment, bathroom and kitchen floor surface shall be constructed and maintained so as to be reasonably impervious to water and so as to permit such floor to be easily kept in a clean and sanitary condition.

7.09. Every plumbing fixture and pipe, every chimney, flue, and smoke pipe, and every other facility, piece of equipment, or utility which is present in a dwelling or dwelling unit, or which is required under this ordinance, shall be constructed and installed in conformance with the appropriate statutes, ordinances and regulations of this (name of corporate unit) and State of _____.

7.10. No owner, operator, or occupant shall cause any service, facility, equipment or utility which is required under this ordinance to be removed from or shut off from or discontinued for any occupied dwelling or dwelling unit let or occupied by him; except for such temporary interruption as may be necessary while actual repairs or alterations are in process, or during temporary emergencies when discontinuance of service is approved by the appropriate authority.

7.11. All construction and materials, ways and means of egress, and installation and use of equipment shall conform to applicable State and local laws dealing with fire protection.

Section VIII. Maximum Density, Minimum Space, Use and Location Requirements

No person shall occupy or let to be occupied any dwelling or dwelling unit, for the purpose of living therein, unless there be compliance with the following requirements:

8.01. The maximum density of occupancy of any dwelling unit by persons shall not exceed either:

8.01.01. One person for each 150 square feet of total habitable room area, except that there shall be at least 100 square feet of total habitable room area for single person occupancy, or

8.01.02. A total number of persons equal to two (2) times the number of its habitable rooms.

8.02. Not more than one family, plus two occupants unrelated to the family, except for guests or domestic employees, shall occupy a dwelling unit unless a permit for a rooming house has been granted by the appropriate authority.

8.03. The ceiling height of any habitable room shall be at least seven (7) feet; except that in any habitable room under a sloping ceiling at least one half of the floor area shall have a ceiling height of at least 7 feet, and the floor area of that part of such a room where the ceiling height is less than 5 feet shall not be considered as part of the floor area in computing the total floor area of the room for the purpose of determining the maximum permissible occupancy.

8.04. No space located partially or totally below grade shall be used as a habitable room of a dwelling unit unless approved by the Health Officer in writing and unless:

8.04.01. The floor and those portions of the walls below grade be of water proof and damp proof construction.

8.04.02. The minimum window area be equal to at least that required in subsection 5.01; and such window area be located entirely above the grade of the ground adjoining such window area, or if windows be located wholly or partly below grade, there be constructed a properly drained window well whose open area is equal to or greater than the area of the masonry opening for the window; the bottom of the window well be below the top of the impervious masonry construction under this window, and the minimum horizontal distance at a right angle from any point of the window well be equal to or greater than the vertical depth of the window well as measured from the bottom of the masonry opening for the window; except where there be supplied adequate artificial illumination.

8.04.03. The total openable window area in each room be equal to at least the minimum as required under subsection 5.02 of this ordinance, except where some other approved devices affording adequate ventilation and humidity control be supplied.

8.04.04. There be no pipes, ducts or other obstructions less than 6 feet, 8 inches above the floor level which interfere with the normal use of the room or area.

8.05. In every dwelling unit of two or more rooms, every room occupied for sleeping purposes shall contain at least 70 square feet of floor space for the first occupant, and at least 50 square feet of floor space for each additional occupant thereof.

8.06. No dwelling or dwelling unit containing two or more sleeping rooms shall have such room arrangements that access to a bathroom or water closet compartment intended for use by occupants of more than one sleeping room can be had only by going through another sleeping room; nor shall room arrangements be such that access to a sleeping room can be had only by going through another sleeping room or a bathroom or water closet compartment.

8.07. Every dwelling unit shall have at least four (4) square feet of floor-to-ceiling height closet space for the personal effects of each permissible occupant; if it be lacking, in whole or in part, an amount of space equal in square footage to the deficiency shall be subtracted from the area of habitable room space used in determining permissible occupancy.

Section IX. Rooming House, Dormitory Rooms, Rooming Units

No person shall operate a rooming house, or shall occupy or let to another for occupancy any dormitory room and/or rooming unit in any rooming house, which is not in compliance with the provisions of every section of this ordinance except the provisions of Section III, Section IV, and paragraphs 8.01, 8.02, 8.05, and 8.07. No owner or other person shall occupy or let to another person any rooming unit or dormitory room unless it be clean and sanitary, and complies with all applicable requirements of (name of corporate unit), including the following:

9.01. No person shall operate a rooming house unless he holds a valid rooming house permit issued by the appropriate authority in the name of the operator and for the specific dwelling or dwelling unit. The operator shall apply to the appropriate authority upon compliance by the operator with the applicable provisions of this ordinance and of any rules and regulations adopted pursuant thereto. This permit shall be displayed in a conspicuous place within the rooming house at all times. No such permit shall be transferable. Every person holding such a permit shall give notice in writing to the appropriate authority within 24 hours after having sold, transferred, given away, or otherwise disposed of ownership of, interest in, or control of any rooming house. Such notice shall include the name and address of the person succeeding to the ownership or control of such rooming house. Every rooming house permit shall expire at the end of one year following its date of issuance, unless sooner suspended or revoked as hereinafter provided.

9.02. At least one flush water closet, lavatory basin and bathtub or shower, properly connected to a water and sewer system approved by the Health Officer and in good working condition, shall be supplied for each six persons or fraction thereof residing within a rooming house, including members of the operator's family wherever they share the use of the said facilities, provided:

9.02.01. That in a rooming house where rooms are let only to males, flush urinals may be substituted for not more than one-half the required number of water closets.

9.02.02. That all such facilities shall be so located within the dwelling as to be reasonably accessible from a common hall or passageway to all persons sharing such facilities.

9.02.03. That every lavatory basin and bathtub or shower shall be supplied with heated and unheated water under pressure at all times.

9.02.04. That no such facilities shall be located in a basement.

9.03. The following provision shall apply in all rooming houses:

9.03.01. Cooking in dormitory rooms and rooming units is prohibited.

9.03.02. Communal cooking and dining facilities in a rooming house is prohibited, except as approved by the Health Officer in writing.

9.03.03. Access doors to rooming unit shall have operating locks to insure privacy.

9.04. Unless exempted by the Health Officer in writing, the operator of every rooming house shall change supplied bed linen and towels therein at least once a week and prior to the letting of any room to any occupant,and the operator shall be responsible for the maintenance of all supplied bedding in a clean and sanitary manner.

9.05. Every room in a rooming house used for living or sleeping purposes shall comply with all the requirements of this ordinance pertaining to a habitable room.

9.05.01. Every room occupied for sleeping purposes by one person shall contain at least 80 square feet of floor space, and every room occupied for sleeping purposes by more than one person shall contain at least 68 square feet of floor space for each occupant thereof; every such room shall also contain at least four (4) square feet of floor-to-ceiling height closet space per occupant thereof, or if it be lacking, in whole or in part, an amount of space equal in square footage to the deficiency shall be subtracted from the area of habitable room space used in determining permissible occupancy except that in a dormitory room said closet or closet

space may be provided in another portion of the rooming house.

9.06. Every rooming unit shall have immediate access to two or more safe, unobstructed means of egress, with minimum head room of six feet six inches, lead to safe and open space at ground level, as required by the law of this State and this (name of corporate unit).

9.07. Structurally sound hand rails shall be provided on any steps containing five risers or more. If steps be not enclosed,hand rails and balusters spaced no more than 6 inches apart shall be provided. Porches and/or balconies located more than three feet higher than the adjacent areas shall have structurally sound protective hand rails (30-36 inches) high and if unenclosed,balusters spaced no more than 6 inches apart shall also be provided.

(Administrative and Enforcement Sections)

Section X. Adoption of Plans of Inspection by the (Appropriate Agency)

10.01. The (Appropriate Agency) is hereby authorized and directed to develop and adopt plans for the inspection of dwelling units subject to the provisions of this ordinance, including:

(a) A plan for the periodic inspection of multiple dwellings and rooming houses subject to the provisions of Section XII, governing the licensing of the operation of such dwellings;

(b) A plan for the systematic inspection of dwelling units contained in such contiguous areas within this (Name of Corporate Unit) as may from time to time be designated by the (Appropriate Agency).

Section XI. Inspections: Powers and Duties of the (Appropriate Authority)

11.01. The (Appropriate Authority) is hereby authorized and directed to make inspections pursuant to one or more of the plans for inspection authorized by Section 10.01; or in response to a complaint that an alleged violation of the provisions of this ordinance or of the applicable rules or regulations pursuant thereto has been committed; or when the (Appropriate Authority) has valid reason to believe that a violation of this ordinance or any rules and regulations pursuant thereto has been committed.

11.02. The (Appropriate Authority) is hereby authorized to enter and inspect between the hours of 8:00 a.m. and 5:00 p.m. all dwellings, dwelling units, and rooming houses, rooming units, and dormitory rooms subject to the provisions of this ordinance for the purpose of determining whether there be compliance with its provisions.

11.03. The (Appropriate Authority) is hereby authorized to inspect the premises surrounding dwellings, dwelling units, rooming houses, rooming units, and dormitory rooms subject to this ordinance, for the purpose of determining whether there is compliance with its provisions.

11.04. The (Appropriate Authority) and the owner, occupant or other person in charge of a dwelling, dwelling unit, rooming unit, rooming house or dormitory room subject to this ordinance may agree to an inspection by appointment at a time other than the hours provided by this ordinance.

11.05. The owner, occupant or other person in charge of a dwelling, dwelling unit, rooming unit, rooming house or dormitory room upon presentation by the (Appropriate Authority) of proper identification, a copy of any relevant plan of inspection pursuant to which entry is sought, and a schedule of the specific areas and facilities to be inspected shall give the (Appropriate Authority) entry and free access to every part of the dwelling, dwelling unit, rooming unit or dormitory room or to the premises surrounding any of these. Before making inspections within a contiguous area pursuant to a plan authorized in Section 10.01 (b), the (Appropriate Authority) shall first consult with organizations representative of property owners and other residents of such contiguous area, if any such organizations exist.

11.06. The (Appropriate Authority) shall keep confidential all evidence not related to the purposes of this ordinance and any rules and regulations pursuant thereto which he may discover in the course of the inspection. Such evidence shall be considered privileged, and shall not be admissible in any judicial proceeding, without the consent of the owner, occupant, or other person in charge of the dwelling unit or rooming unit so inspected.

11.07. If any owner, occupant, or other person in charge of a dwelling, dwelling unit or rooming unit, or a multiple dwelling or rooming house subject to the provisions of Section XII refuses, impedes, inhibits, interferes with, restricts, or obstructs entry and free access to every part of the structure or premises where inspection authorized by this ordinance is sought, the (Appropriate Authority) may seek in a court of competent jurisdiction an order that such owner, occupant or other person in charge cease and desist with such interference.

Section XII. Licensing of the Operation of Multiple Dwellings and Rooming Houses

12.01. No person shall operate a multiple dwelling or rooming house unless he holds a current, unrevoked operating license issued by the (Appropriate Authority) in his name for the specific named multiple dwelling or rooming house.

12.02. Every operating license shall be issued for a period of one year from its date of issuance unless sooner revoked, and may be renewed for successive periods of not to exceed one year.

12.03. The (Appropriate Authority) is hereby authorized, upon application therefor to issue new operating licenses, and renewals thereof, in the names of applicant owners of multiple dwellings and rooming houses. No such licenses shall be issued unless the multiple dwelling or rooming house in connection with which the license is sought be found after inspection to meet the requirements of this ordinance and of applicable rules and regulations pursuant thereto.

12.04. No operating license shall be issued or renewed unless the applicant owner has first made application therefor on an application form provided by the (Appropriate Authority). The (Appropriate Authority) shall develop such forms and make them available to the public.

12.05. No operating license shall be issued or renewed unless the applicant owner agrees in his application to such inspections pursuant to Sections 10.01 and 11.01 as the (Appropriate Authority) may require to determine whether the multiple dwelling or rooming house in connection with which such license is sought be in compliance with the provisions of this ordinance and with applicable rules and regulations pursuant thereto.

12.06. No operating license shall be issued or renewed unless the completed application form be accompanied by payment of a license fee of _____ dollars.

12.07. No operating license shall be issued or renewed for a nonresident applicant, unless such applicant designates in writing the (Appropriate Local Official) his agent for the receipt of service of notice of violation of the provisions of this ordinance and for service of process pursuant to this ordinance.

12.08. No operating license shall be issued or renewed for a resident applicant, unless such applicant has first designated an agent for the receipt of service of violations of the provisions of this ordinance and for service of process pursuant to this ordinance, when said applicant is absent from this (Name of corporate unit) for thirty (30) or more days. Such a designation shall be made in writing, and shall accompany each application form. The applicant may designate any person resident in this (Name of corporate unit) his agent for this purpose, or may designate the (Appropriate Local Official) his agent for this purpose.

12.09. No operating license shall be renewed unless an application therefor has been made within sixty (60) days prior to the expiration of the present operating license.

12.10. Each license shall be displayed in a conspicuous place within the common ways of the multiple dwelling or rooming house. No license shall be transferable to another person, or to another multiple dwelling or rooming house. Every person holding an operating license shall give notice in writing to the (Appropriate Authority) within twenty-four (24) hours after having transferred or otherwise disposed of the legal control of any licensed multiple dwelling or rooming house. Such notice shall include the name and address of the person or persons succeeding to the ownership or control of such multiple dwelling or rooming house.

12.11. Every owner or other person in charge of a licensed multiple dwelling or rooming house shall keep, or cause to be kept, records of all requests for repair and complaints by tenants, which are related to the provisions of this ordinance and to any applicable rules and regulations, and of all corrections made in response to such requests and complaints. Such records shall be made available by the owner or other person in charge to the (Appropriate Authority) for inspection and copying upon demand. Such records shall be admissible in any administrative or judicial proceeding pursuant to the provisions of this ordinance as prima facie evidence of the violation or the correction of violation of this ordinance or applicable rules and regulations pursuant thereto.

12.12. Whenever, upon inspection of the licensed multiple dwelling or rooming house, or of the records required to be kept by Section 12.11, the (Appropriate Authority) finds that conditions or practices exist which are in violation of the provisions of this ordinance or of any applicable rules and regulations pursuant thereto, he shall serve the owner or other person in charge with notice of such violation in the manner hereinafter provided. Such notice shall state that unless the violations cited be corrected within reasonable time, the operating license may be suspended.

12.13. At the end of the time he has allowed for correction of any violation cited, the

(Appropriate Authority) shall reinspect the multiple dwelling or rooming house, and if he determines that such conditions have not been corrected, he may issue an order suspending the operating license.

12.14. Any person whose operating license has been suspended shall be entitled, if the (Appropriate Authority) so determines, to a reconsideration of the order or a formal hearing, in the manner hereinafter provided by this ordinance. If no request for reconsideration or petition for hearing reaches the (Appropriate Authority) within twenty-one (21) days following the issuance of the order of suspension, the license shall be revoked, except that prior to revocation any person whose license has been suspended may request reinspection, upon a showing that the violation or violations cited in the notice have been corrected.

12.15. If, upon reinspection, the (Appropriate Authority) finds that the multiple dwelling or rooming house in connection with which the notice was issued is now in compliance with this ordinance and with applicable rules and regulations issued pursuant thereto, he shall reinstate the license. A request for reinspection shall not extend the suspension period, unless the (Appropriate Authority) grants such request.

Section XIII. Rules and Regulations

13.01. The (Appropriate Authority) is hereby authorized to make, adopt, revise and amend such rules and regulations as it deems necessary for the carrying out of the purposes of this ordinance.

Section XIV. Notice of Violation

14.01. Whenever the (Appropriate Authority) determines that any dwelling, dwelling unit, or rooming unit, or the premises surrounding any of these, fails to meet the requirements set forth in this ordinance or in applicable rules and regulations issued pursuant thereto, he shall issue a notice setting forth the alleged failures, and advising the owner, occupant or other person in charge that such failures must be corrected. This notice shall:

14.01.01. Be in writing.

14.01.02. Set forth the alleged violations of this ordinance or of applicable rules and regulations issued pursuant thereto.

14.01.03. Describe the dwelling, dwelling unit or rooming unit where the violations are alleged to exist or to have been committed.

14.01.04. Provide a reasonable time, not to exceed sixty (60) days, for the correction of any violation alleged.

14.01.05. Be served upon the owner, occupant or other person in charge of the dwelling, dwelling unit, or rooming unit personally, or by registered mail, return receipt requested, addressed to the last known place of residence of the owner, occupant or other person in charge. If one or more persons to whom such notice is addressed cannot be found after diligent effort to do so, service may be made upon such person or persons by posting a notice in or about the dwelling, dwelling unit or rooming unit described in the notice, or by causing such notice to be published in a newspaper of general circulation for a period of _____ consecutive days; or

14.01.06. Be served upon a resident agent for the receipt of such service of notice designated pursuant to Section 12.08; or

14.01.07. Be served upon the (Appropriate Local Official) where he has been designated agent for such service pursuant to Section 12.07.

14.02. At the end of the period of time allowed for the correction of any violation alleged, the (Appropriate Authority) shall reinspect the dwelling, dwelling unit or rooming unit described in the notice.

14.03. If, upon reinspection, the alleged violations are determined by the (Appropriate Authority) not to have been corrected, he shall issue a second notice of violation which shall constitute an order requiring that the then existing failures to meet the requirements of this ordinance or of applicable existing rules or regulations issued pursuant thereto, shall be corrected within a reasonable time allowed, but not to exceed sixty (60) days after the date of such reinspection, if the person served with such notice does not request a reconsideration or petition for a hearing on the matter in the manner hereinafter provided.

14.04. The (Appropriate Authority) shall cause a copy of the second notice to be posted in a conspicuous place in or about the dwelling, dwelling unit or rooming unit where the violations are alleged to exist, and shall serve it in the manner provided in Sections 14.01.01 - 14.01.07.

14.05. The (Appropriate Authority), after the expiration of time granted the person served with such second notice to seek reconsideration or a hearing in the manner hereinafter provided by this ordinance, or after a final decision adverse to such person served has been rendered by the (Hearing Agency) or by (a court of competent jurisdiction) to which an appeal has been taken, shall cause the second notice to be recorded in the (registry of deeds).

14.06. All subsequent transferees of the dwelling, dwelling unit or rooming unit in connection with which a second notice has been so recorded shall be deemed to have notice of the continuing existence of the violations alleged, and shall be liable to all penalties and procedures provided by this ordinance and by applicable rules and regulations issued pursuant thereto to the same degree as was their transferor.

Section XV. Civil Penalties

15.01. Any owner, occupant or other person in charge of a dwelling, dwelling unit or rooming unit who has received the second order or notice of a violation of this ordinance may be subject to a civil penalty of _____ dollars per day for each day the violation continues after expiration of the specified reasonable consideration period, or to _____ days in jail, or to both, provided that no such penalty shall be applicable while a reconsideration, hearing or appeal to a court of competent jurisdiction is pending in the matter.

Section XVI. Repairs; Demolition; Revolving Fund

16.01. Repairs.

16.01.01. Whenever an owner or other person in charge of a dwelling, dwelling unit or rooming unit fails, neglects or refuses to make repairs called for by a second order or notice of violation issued pursuant to Section 14.03, the (Appropriate Authority) may undertake such repairs, when in its judgement a failure to make them will endanger the public health, safety or welfare, and the cost of such repairs will not exceed fifty percent (50%) of the fair market value of the structure to be repaired.

16.01.02. Notice of the intention to make such repairs shall be served upon the owner or other person in charge pursuant to Section 14; or upon the (Appropriate Local Official) as designated agent for service pursuant to Section 12.07; or upon the resident agent of the owner, as designated agent for service pursuant to Section 12.08.

16.01.03. Every owner or other person in charge of a dwelling, dwelling unit or rooming unit who has received notice of the intention of the (Appropriate Authority) to make repairs shall give entry and free access to the agent of the (Appropriate Authority) for the purpose of making such repairs. Any owner or other person in charge of a dwelling, dwelling unit or rooming unit who refuses, impedes, interferes with, hinders or obstructs entry by such agent pursuant to a notice of intention to make repairs shall be subject to a civil penalty of twenty-five dollars ($25) for each such failure to comply with this section.

16.01.04. When repairs are made at the direction of the (Appropriate Authority), cost of such repairs shall constitute a debt in favor of this (Name of Corporate Unit) against the owner of the repaired structure. In the event such owner fails, neglects or refuses to pay this (Name of Corporate Unit) the amount of this debt, it shall be recoverable in a civil action, against the owner or his successor, brought in a court of competent jurisdiction by this (Name of Corporate Unit) which shall possess all rights of a private creditor.

16.02. Demolition.

16.02.01. Any dwelling, dwelling unit or rooming unit shall be declared unfit for human habitation when, in the judgment of the (Appropriate Authority), it is so damaged, decayed, dilapidated, insanitary, unsafe or vermin-infested as to create a hazard to the health, safety and welfare of the occupants or of the public, and where the structure is determined by the (Appropriate Authority) not to warrant repair under Section 16.01.

16.02.02. Any vacant building shall be declared unfit for human habitation, when its existence, in the judgment of the (Appropriate Authority) is detrimental to the public health, safety or welfare.

16.02.03. The owner of any structure which has been determined unfit for human habitation, whether such structure be occupied or vacant, shall be given notice of this determination in the manner provided for service of notice in Section 14, and shall be given a reasonable time, not to exceed ninety (90) days, to remove such structure.

16.02.04. The owner of any dwelling, dwelling unit or rooming unit contained in any structure which has been determined unfit for human habitation and which has been vacated shall not cause or permit such vacated dwelling, dwelling unit or rooming unit to be reoccupied

pending removal of the structure.

16.02.05. Any owner aggrieved by the notice to demolish may within _____ days seek a reconsideration of the matter in the manner hereinafter provided, and may seek a formal hearing in the manner provided in Section 18.

16.02.06. When the owner fails, neglects or refuses to remove the unfit structure within the requisite time, the (Appropriate Authority) may apply to a court of competent jurisdiction for a demolition order. The court may grant such order when no reconsideration or hearing on the matter is pending. The cost of such demolition shall create a debt in favor of this (Jurisdiction) against such owner, and shall be recoverable in a civil action brought by this (Jurisdiction) which shall possess all the rights of a private creditor.

16.02.07. All demolition, whether carried out by the owner or by the (Appropriate Authority) shall include the filling in of the excavation remaining on the property on which the demolished structure was located, in such manner as to eliminate all potential danger to the public health, safety or welfare arising from such excavation.

16.03. Revolving Fund.

16.03.01. There is hereby created a revolving fund for the purpose of supporting the cost of repairs or demolition made by the (Appropriate Authority) pursuant to Section 16.01 and 16.02. Into this fund shall be paid:

(a) All civil penalties collected for violations of this ordinance pursuant to Section 15.

(b) All license fees collected pursuant to Section 12.06.

(c) All judgments collected in actions to recover the costs of repair and demolition, pursuant to Sections 16.01.04 and 16.02.06.

(d) Such other revenues as this (Jurisdiction) may from time to time authorize to be paid into this fund.

(e) All donations and grants designed to promote the purposes of this ordinance, from public or private sources. The (Appropriate Authority) is hereby declared to be the authorized agency of this (Jurisdiction) to apply for and receive all grants, loans and gifts of funds to promote the purposes of this ordinance.

Section XVII. Collection and Dissemination of Information

17.01. The (Appropriate Authority) is hereby authorized to collect and disseminate information concerning techniques of maintenance, repair, and sanitation in housing, and concerning the requirements of this ordinance and applicable rules and regulations issued pursuant thereto.

Section XVIII. Applications for Reconsideration; Conferences; Hearings; Appeals

18.01. (Alternative A) (Application for Reconsideration).

18.01.01. Any person aggrieved by a notice of the (Appropriate Authority) issued in connection with any alleged violation of this ordinance or of applicable rules and regulations issued pursuant thereto, or by any order requiring repair or demolition pursuant to Sections 16.01 or 16.02, may apply to the (Appropriate Authority) for a reconsideration of such notice or order within twenty-one (21) days after it has been issued.

18.01.02. The (Appropriate Authority) shall set a time and place for an informal conference on the matter within ten (10) days of the receipt of such application, and shall advise the applicant of such time and place in writing.

18.01.03. At the informal conference, the applicant shall be permitted to present his grounds for believing that the order should be revoked or modified to one or more representatives of the (Appropriate Authority).

18.01.04. Within ten (10) days following the close of the informal conference,the (Appropriate Authority) shall advise the applicant whether or not it will modify or set aside the notice or order issued by the (Appropriate Authority).

18.01. (Alternative B) (Formal Conference; Referees).

18.01.01. Any person aggrieved by a notice of the (Appropriate Authority) issued in connection with any alleged violation of this ordinance or of applicable rules and regulations issued pursuant thereto, or by any order requiring repair or demolition pursuant to Sections 16.01 and 16.02, may petition the (Appropriate Authority) for a conference on the matter. The petition may be filed by means of a letter, setting forth the petitioner's grounds for contesting the notice or order and must be received by the (Appropriate Authority) within twenty-one (21) days after such notice or order was served on the petitioner.

18.01.02. The (Appropriate Authority) shall set a time and place for the conference and shall advise the petitioner in writing of such time and place, within ten (10) days of the receipt of his petition.

18.01.03. The (Appropriate Authority) shall designate one or more referees to preside at such conference.

18.01.04. The referee is hereby authorized to administer oaths and affirmations and to subpoena any witnesses or documents, which may be introduced before him.

18.01.05. A verbatim record of the proceedings before the referee shall be kept for each conference.

18.01.06. Within ten (10) days following the close of each conference, the referee shall affirm, set aside or modify the notice or order contested by the petitioner, and shall advise the petitioner and the (Hearing Agency) of his decision in writing.

18.02. Hearings (Alternative A) (For use with reconsideration procedure).

18.02.01. Any person aggrieved by a notice of the (Appropriate Authority) issued in connection with any alleged violation of the provisions of this ordinance or of any applicable rules and regulations pursuant thereto, or by any order requiring repair or demolition pursuant to Sections 16.01 and 16.02, may file with the (Hearing Agency) a petition setting forth his reasons for contesting the notice or order.

18.02.02. Such petition shall be filed within twenty-one (21) days after the notice or order is served on petitioner in the manner prescribed by Section 14.

18.02.03. Upon receipt of a valid petition, the (Hearing Agency) shall either grant or deny the hearing requested, and shall advise petitioner of its decision in writing within ten (10) days of the day on which his petition was received.

18.02.04. When the (Hearing Agency) determines to hold a hearing, it shall serve the petitioner with notice of its decision in the manner provided for service of notice in Section 14. Such notice shall be served within ten (10) days of the receipt of the petition.

18.02.05. At the hearing, the petitioner shall be given an opportunity to show cause why the notice or order should be modified or withdrawn, or why the period of time permitted for compliance should be extended.

18.02.06. The (Hearing Agency) shall have the power to affirm, modify or revoke the notice or order, and may grant an extension of time for the performance of any act required of not more than _____ additional month, where the (Hearing Agency) finds that there is practical difficulty or undue hardship connected with the performance of any act required by the provisions of this ordinance or by applicable rules or regulations issued pursuant thereto, and that such extension is in harmony with the general purpose of this ordinance to secure the public health, safety and welfare.

18.02.07. The (Hearing Agency) may grant variances from the provisions of this ordinance or from applicable rules and regulations issued pursuant thereto when the (Hearing Agency) finds that there is practical difficulty or unnecessary hardship connected with the performance of any act required by this ordinance and applicable rules and regulations pursuant thereto; that strict adherence to such provisions would be arbitrary in the case at hand; that extension would not provide an appropriate remedy in the case at hand, and that such variance is in harmony with the general purpose of this ordinance to secure the public health, safety and welfare.

18.02. Hearing (Alternative B) (For use with formal conference procedure).

18.02.01. Any person aggrieved by the decision of the referee may file a petition for hearing before the (Hearing Agency) within twenty-one (21) days after such decision has been rendered and served upon petitioner in the manner prescribed for the service of notice in Section 14.

18.02.02. Upon receipt of a valid petition, the (Hearing Agency) shall grant the hearing requested, and shall advise petitioner of its decision in writing within ten (10) days of the day on which his petition was received.

18.02.03. When the (Hearing Agency) determines to hold a hearing it shall serve the petitioner with notice of its decision in the manner provided for service of notice in Section 14. The (Hearing Agency) shall also notify the (Appropriate Authority) of its determination, and shall request that a transcript of the record of the conference held pursuant to Section 18.01 be filed with the (Hearing Agency) within _____ days of the announcement of the decision.

18.02.04. At the hearing, the petitioner shall be given an opportunity to show cause why the notice or order should be modified or withdrawn, or why the period of time permitted for compliance should be extended.

18.02.05. The hearing shall be on the record of the conference. The (Hearing Agency) after consideration of the record as a whole, may affirm, modify or revoke the notice or order, and may grant an extension of time for the performance of any act of not more than _____ additional months, where the (Hearing Agency) finds that there is practical difficulty or undue hardship connected with the performance of any act required by the provisions of this ordinance or by applicable rules or regulations issued pursuant thereto, and that such extension is in harmony with the general purpose of this ordinance to secure the public health, safety and welfare.

18.02.06. The (Hearing Agency) may grant variances from the provisions of this ordinance or from applicable rules and regulations issued pursuant thereto, when the (Hearing Agency) finds that there is practical difficulty or undue hardship connected with the performance of any act required by this ordinance and applicable rules and regulations pursuant thereto; that strict adherence to such provisions would be arbitrary in the case at hand; that extension would not provide an appropriate remedy in the case at hand; and that such variance is in harmony with the general purpose of this ordinance to secure the public health, safety and welfare.

18.03. Any person aggrieved by the final decision of the (Hearing Agency) may obtain judicial review by filing in a court of competent jurisdiction within _____ days of the announcement of such decision a petition praying that the decision be set aside in whole or in part. A copy of each petition so filed shall be forthwith transmitted to the (Hearing Agency) which shall file in court a record of the proceedings upon which it based its decision. Upon the filing of such record, the court shall affirm, modify, or vacate the decision complained of in whole or in part. The findings of (Hearing Agency) with respect to questions of fact shall be sustained if supported by substantial evidence on the record, considered as a whole.

Section XIX. Emergencies.

19.01. Whenever, in the judgment of the (Appropriate Authority) an emergency exists which requires immediate action to protect the public health, safety or welfare, he may, without notice, conference or hearing issue an order directing the owner, occupant, or other person in charge of the structure to which the provisions of this ordinance or applicable rules and regulations pursuant thereto apply to take such action as is necessary to correct or abate the emergency; or, if circumstances warrant, may himself act to abate or correct it.

19.02. The owner, occupant or other person in charge of such structure shall be granted a conference on the matter upon his request, as soon as practicable, but such conference shall in no case stay the abatement of correction of such emergency.

Recommended Ordinance Governing Mobile Home Parks and Travel Trailer Parking Areas, 1966, U.S. Public Health Service

An Ordinance defining, regulating, and enforcing minimum standards for mobile home parks or travel trailer parking areas; establishing minimum standards governing design, construction, alteration, extension and maintenance of mobile home parks or travel trailer parking areas and related utilities, facilities, and other physical things and conditions required to make such parks and areas safe, sanitary, and fit for human habitation; authorizing the issuance of permits for construction, alteration and extension of mobile home parks or travel trailer parking areas; authorizing the licensing of operators of mobile home parks or travel trailer parking areas and fixing the responsibilities and duties of such owners and operators; authorizing the inspection of mobile home parks or travel trailer parking areas; and fixing penalties for violations.

[Since there are some differences between the regulations governing mobile home parks and travel trailer parking areas, although most of the regulations for them are the same, the differences will be indicated in the following manner:

1. Those regulations pertaining to only mobile home parks will be placed in parenthesis.

2. Those regulations pertaining to only travel trailer parking areas will be placed in double parenthesis.]

Be it, therefore, ordained by the (name of municipality) as follows:

Section I: Definitions

As used in this ordinance:

a. Health Authority means the legally designated health authority or its authorized representative of (name of municipality).

b. License means a written license issued by the health authority allowing a person to operate and maintain a mobile home park or travel trailer parking area under the provisions of this Ordinance and regulations issued hereunder.

c. (Mobile Home means a transportable, single-family dwelling unit suitable for year-round occupancy and containing the same water supply, waste disposal and electrical conveniences as immobile housing.)

d. (Mobile Home Lot means a parcel of land for the placement of a single mobile home and the exclusive use of its occupants.)

e. (Mobile Home Park means a parcel of land under single ownership which has been planned and improved for the placement of mobile homes for non-transient use.)

f. (Mobile Home Stand means that part of an individual lot which has been reserved for the placement of the mobile home, appurtenant structures or additions.)

g. Permit means a written permit issued by the health authority permitting the construction, alteration and extension of a mobile home park or travel trailer parking area under the provisions of this Ordinance and regulations issued hereunder.

h. Person means an individual, firm, trust, partnership, public or private association or corporation.

i. ((Sanitary Station means a facility used for removing and disposing of wastes from trailer holding tanks.))

j. Service Building means a structure housing toilet, lavatory and such other facilities as may be required by this Ordinance.

k. ((Service Sink means a slop sink with a flushing rim for the disposal of liquid wastes from trailers.))

l. Sewer Connection means the connection consisting of all pipes, fittings and appurtenances from the drain outlet of the mobile home or travel trailer to the inlet of the corresponding sewer riser pipe of the sewerage system serving the mobile home park or travel trailer parking area.

m. Sewer Riser Pipe means that portion of the sewer lateral which extends vertically to the ground elevation and terminates at each mobile home lot or travel trailer parking space.

n. ((Trailer means any of the following:))

1. ((Travel Trailer means a vehicular, portable structure built on a chassis, designed to be used as a temporary dwelling for travel, recreational and vacation uses, permanently identified Travel Trailer by the manufacturer of the trailer and, when factory equipped for the road, it shall have a body width not exceeding eight feet, and a body length not exceeding 32 feet.))

2. ((Pick-Up Coach means a structure designed to be mounted on a truck chassis for use as a temporary dwelling for travel, recreation and vacation.))

3. ((Motor-Home means a portable, temporary dwelling to be used for travel, recreation and vacation, constructed as an integral part of a self-propelled vehicle.))

4. ((Camping Trailer means a canvas, folding structure, mounted on wheels and designed for travel, recreation and vacation use.))

5. ((Dependent Trailer means a trailer which is dependent upon a service building for toilet and lavatory facilities.))

6. ((Self-Contained Trailer means a trailer which can operate independent of connections to sewer, water and electric systems. It contains a water-flushed toilet, lavatory, shower and kitchen sink, all of which are connected to water storage and sewage holding tanks located within the trailer.))

7. ((Travel Trailer Parking Area means a parcel of land in which two or more spaces are occupied or intended for occupancy by trailers for transient dwelling purposes.))

8. ((Trailer Space means a parcel of land in a travel trailer parking area for the placement of a single trailer and the exclusive use of its occupants.))

9. ((Trailer Stand means that part of an individual trailer space which has been reserved for the placement of a single trailer and its accessory structures.))

o. Water Connection means the connection consisting of all pipes, fittings and appurtenances from the water riser pipe to the water inlet pipe of the distribution system within the mobile home or travel trailer.

p. Water Riser Pipe means that portion of the water supply system serving the mobile home park or travel trailer parking area which extends vertically to the ground elevation and terminates at a designated point at each mobile home lot or travel trailer space.

q. ((Watering Station means a facility for supplying water storage tanks of trailers with potable water.))

Section 2: Permits

It shall be unlawful for any person to construct, alter or extend any mobile home park or travel trailer parking area within the limits of (name of municipality) unless he holds a valid permit issued by the health authority in the name of such person for the specific construction, alteration or extension proposed.

All applications for permits shall be made to the health authority and shall contain the following:

a. Name and address of applicant.

b. Interest of the applicant in the mobile home park or travel trailer parking area.

c. Location and legal description of the mobile home park or travel trailer parking area.

d. Complete engineering plans and specifications of the proposed park or area showing:

1. The area and dimensions of the tract of land;
2. The number, location, and size of all mobile home lots or travel trailer parking spaces;
3. The location and width of roadways and walkways;
4. The location of service buildings and any other proposed structures;
5. The location of water and sewer lines and riser pipes;
6. Plans and specifications of the water supply and refuse and sewage disposal facilities;
7. Plans and specifications of all buildings constructed within the mobile home park or travel trailer parking area; and
8. The location and details of lighting and electrical systems.

All applications shall be accompanied by the deposit of a fee of ..... dollars.

When, upon review of the application, the health authority is satisfied that the proposed plan meets the requirements of this Ordinance and regulations issued hereunder, a permit shall be issued.

Any person whose application for a permit under this Ordinance has been denied may request and shall be granted a hearing on the matter before the health authority under the procedure provided by Section 5 of this Ordinance.

Section 3: Licenses

It shall be unlawful for any person to operate any mobile home park or travel trailer parking area within the limits of (name of municipality) unless he holds a valid license issued annually by the health authority in the name of such person for the specific mobile home park or travel trailer parking area. All applications for licenses shall be made to the health authority, who shall issue a license upon compliance by the applicant with provisions of this Ordinance and regulations issued hereunder and of other applicable legal requirements.

Every person holding a license shall give notice in writing to the health authority within twenty-four hours after having sold, transferred, given away, or otherwise disposed of interest in or control of any mobile home park or travel trailer parking area. Such notice shall include the name and address of the person succeeding to the ownership or control of such mobile home park or travel trailer parking area. Upon application in writing for transfer of the license and deposit of a fee of ..... dollars, the license shall be transferred if the mobile home park or travel trailer parking area be in compliance with all applicable provisions of this Ordinance and regulations issued hereunder.

a. Application for original licenses shall be in writing, signed by the applicant, accompanied by an affidavit of the applicant as to the truth of the application and by the deposit of a fee of ..... dollars, and shall contain: the name and address of the applicant; the location and legal description of the mobile home park or travel trailer parking area; and a site plan of the mobile home park or travel trailer parking area showing all mobile home lots or travel trailer spaces, structures, roads, walkways, and other service facilities.

b. Applications for renewals of licenses shall be made in writing by the holders of the licenses, shall be accompanied by the deposit of a fee of ..... dollars and shall contain any change in the information submitted since the original license was issued or the latest renewal granted.

Any person whose application for a license under this Ordinance has been denied may request and shall be granted a hearing on the matter before the health authority under the procedure of Section 5 of this Ordinance.

Whenever, upon inspection of any mobile home park or travel trailer parking area, the health authority finds that conditions or practices exist which are in violation of any provision of this Ordinance or regulations issued hereunder, the health authority shall give notice in writing in accordance with Section 5 to the person to whom the license was issued that unless such conditions or practices be corrected within a reasonable period of time specified in the notice by the health authority, the license shall be suspended. At the end of such period, the health authority shall reinspect such mobile home park or travel trailer parking area, and, if such conditions or practices have not been corrected, he shall suspend the license and give notice in writing of such suspension to the person to whom the license is issued. Upon receipt of notice of such suspension, such person shall cease operation of such mobile home park or travel trailer parking area except as provided in Section 5.

Any person whose license has been suspended, or who has received notice from the health authority that his license will be suspended unless certain conditions or practices at the mobile home park or travel trailer parking area be corrected, may request and shall be granted a hearing on the matter before the health authority, under the procedure provided by Section 5 of this Ordinance; provided that when no petition for such hearing shall have been filed within ten days following the day on which notice of suspension was served, such license shall be deemed to have been automatically revoked at the expiration of such ten-day period.

A temporary license, upon written request therefore, shall be issued by the health authority, for every mobile home park or travel trailer parking area in existence upon the effective date of this Ordinance, permitting the mobile home park or travel trailer parking area to be operated during the period ending 180 days after the effective date of this Ordinance in accordance with such conditions as the health authority may require.

The term of the temporary license shall be extended, upon written request, for not to exceed one additional period of 180 days, if (1) the licensee shall have filed application for a license in conformity with Section 3 of this Ordinance within 90 days after the effective date of this Ordinance; (2) the plans and specifications accompanying the application for license comply with all provisions of this Ordinance and all other applicable ordinances and statutes; (3) the licensee shall have diligently endeavored to make the existing mobile home park or travel trailer parking area conform fully to the plans and specifications submitted with application; and (4) failure to make the existing mobile home park or travel trailer parking area conform fully to such plans and specifications shall have been due to causes beyond the control of the licensee.

Section 4: Inspection of Mobile Home Parks or Travel Trailer Parking Areas

The health authority is hereby authorized and directed to make such inspections as are necessary to determine satisfactory compliance with this Ordinance and regulations issued hereunder.

The health authority shall have the power to enter at reasonable times upon any private or public property for the purpose of inspecting and investigating conditions relating to the enforcement of this Ordinance and regulations issued hereunder.

The health authority shall have the power to inspect the register containing a record of all residents of the mobile home park or travel trailer parking area.

It shall be the duty of the owners or occupants of mobile home parks or travel trailer parking areas, and mobile homes or travel trailers contained therein, or of the person in charge thereof, to give the health authority free access to such premises at reasonable times for the purpose of inspection.

It shall be the duty of every occupant of a mobile home park or travel trailer parking area to give the owner thereof or his agent or employee access to any part of such mobile home park or travel trailer parking area or its premises at reasonable times for the purpose of making such

repairs or alterations as are necessary to effect compliance with this Ordinance and regulations issued hereunder, or with any lawful order issued pursuant to the provisions of this Ordinance.

Section 5: Notices, Hearings and Orders

Whenever the health authority determines that there are reasonable grounds to believe that there has been a violation of any provision of this Ordinance, or regulations issued hereunder, the health authority shall give notice of such alleged violation to the person to whom the permit or license was issued, as hereinafter provided. Such notice shall (a) be in writing; (b) include a statement of the reasons for its issuance; (c) allow a reasonable time for the performance of any act it requires; (d) be served upon the owner or his agent as the case may require: Provided: That such notice or order shall be deemed to have been properly served upon such owner or agent when a copy thereof has been sent by registered mail to his last known address, or when he has been served with such notice by any method authorized or required by the laws of this state; (e) contain an outline of remedial action which, if taken, will effect compliance with the provisions of this Ordinance and regulations issued hereunder.

Any person affected by any notice which has been issued in connection with the enforcement of any provision of this Ordinance, or regulation issued hereunder, may request and shall be granted a hearing on the matter before the health authority: Provided: That such person shall file in the office of the health authority a written petition requesting such hearing and setting forth a brief statement of the grounds therefor within ten days after the day the notice was served. The filing of the request for a hearing shall operate as a stay of the notice and of the suspension except in the case of an order issued under Section 5. Upon receipt of such petition, the health authority shall set a time and place for such hearing and shall give the petitioner written notice thereof. At such hearing the petitioner shall be given an opportunity to be heard and to show why such notice should be modified or withdrawn. The hearing shall be commenced not later than ten days after the day on which the petition was filed: Provided: That upon application of the petitioner the health authority may postpone the date of the hearing for a reasonable time beyond such ten-day period when in his judgment the petitioner has submitted good and sufficient reasons for such postponement.

After such hearing the health authority shall make findings as to compliance with the provisions of this Ordinance and regulations issued hereunder and shall issue an order in writing sustaining, modifying or withdrawing the notice which shall be served as provided in Section 5. Upon failure to comply with any order sustaining or modifying a notice, the license of the mobile home park or travel trailer parking area affected by the order shall be revoked.

The proceedings at such a hearing, including the findings and decision of the health authority, and together with a copy of every notice and order related thereto shall be entered as a matter of public record in the office of the health authority but the transcript of the proceedings need not be transcribed unless judicial review of the decision is sought as provided by this Section. Any person aggrieved by the decision of the health authority may seek relief therefrom in any court of competent jurisdiction, as provided by the laws of the State.

Whenever the health authority finds that an emergency exists which requires immediate action to protect the public health, he may without notice or hearing issue an order reciting the existence of such an emergency and requiring that such action be taken as he may deem necessary to meet the emergency including the suspension of the permit or license. Notwithstanding any other provisions of this Ordinance, such order shall be effective immediately. Any person to whom such an order is directed shall comply therewith immediately, but upon petition to the health authority shall be afforded a hearing as soon as possible. The provisions of Section 5 shall be applicable to such hearing and the order issued thereafter.

Section 6: Adoption of Regulations by the Health Authority

The health authority is hereby authorized to make and, after public hearing, to adopt such written regulations as may be necessary for the proper enforcement of the provisions of this Ordinance. Such regulations shall have the same force and effect as the provision of this Ordinance, and the penalty for violation of the provisions thereof shall be the same as the penalty for violation of the provisions of this Ordinance, as hereinafter provided.

Section 7: Environmental, Open Space and Access Requirements

General Requirements

Condition of soil, ground water level, drainage and topography shall not create hazards to the property or the health or safety of the occupants. The site shall not be exposed to objectionable smoke, noise, odors or other adverse influences, and no portion subject to unpredictable and/or sudden flooding, subsidence or erosion shall be used for any purpose which would expose persons or property to hazards.

Soil and Ground Cover Requirements

Exposed ground surfaces in all parts of every mobile home park or travel trailer parking area shall be paved, or covered with stone screenings, or other solid material, or protected with a vegetative growth that is capable of preventing soil erosion and of eliminating objectionable dust.

(Site Drainage Requirements

(The ground surface in all parts of every mobile home shall be graded and equipped to drain all surface water in a safe, efficient manner.)

(Park Areas for Nonresident Uses

(a. No part of any park shall be used for nonresidential purposes, except such uses that are required for the direct servicing and well being of park residents and for the management and maintenance of the park.)

(b. Nothing contained in this Section shall be deemed as prohibiting the sale of a mobile home located on a mobile home stand and connected to the pertinent utilities.)

(Required Separation Between Mobile Homes or Travel Trailers

(a. Mobile homes shall be separated from each other and from other buildings and structures by at least 15 feet; provided that mobile homes placed end-to-end may have a clearance of 10 feet where opposing rear walls are staggered.)

(b. An accessory structure which has a horizontal area exceeding 25 square feet, is attached to a mobile home or located within 10 feet of its window, and has an opaque top or roof that is higher than the nearest window shall, for purposes of all separation requirements, be considered to be part of the mobile home.)

((Trailers shall be separated from each other and from other structures by at least 10 feet. Any accessory structure such as attached awnings, carports, or individual storage facilities shall, for purposes of this separation requirement, be considered to be part of the trailer.))

((Density Requirement

((The density shall not exceed 25 trailer spaces per acre of gross site area except that the health authority may, under special circumstances, permit a higher density provided all other environmental, open space, and access requirements of this Ordinance and regulations issued hereunder are adhered to. Any person desiring a higher density shall make application for such exemption to the health authority, specifying the reasons therefor. If a higher density be permitted, the health authority shall issue a special license specifying the location of the parking area, the expiration date of the license, and the conditions of issuance.))

(Required Recreation Areas

(a. In all parks accommodating or designed to accommodate 25 or more mobile homes, there shall be one or more recreation areas which shall be easily accessible to all park residents.)

(b. The size of such recreation areas shall be based upon a minimum of 100 square feet for each lot. No outdoor recreation area shall contain less than 2,500 square feet.)

(c. Recreation areas shall be so located as to be free of traffic hazards and should, where the topography permits, be centrally located.)

((d. In all travel trailer parking areas there shall be at least one recreation area which shall be easily accessible from all trailer spaces. The size of such recreation area shall be not less than eight percent of the gross site area or 2,500 square feet, whichever is greater.))

Required Setbacks, Buffer Strips and Screening

a. All mobile homes or travel trailers shall be located at least 25 feet from any park or area property boundary line abutting upon a public street or highway and at least 15 feet from other park or area property boundary lines.

(b. There shall be a minimum distance of 10 feet between an individual mobile home and adjoining pavement of a park street, or common parking area or other common areas.)

(c. All mobile home parks located adjacent to industrial or commercial land uses shall be provided with screening such as fences or natural growth along the property boundary line separating the park and such adjacent nonresidential uses.)

(Park Street System

(a. General Requirements: All mobile home parks shall be provided with safe and convenient vehicular access from abutting public streets or roads to each mobile home lot. Alignment and gradient shall be properly adapted to topography.)

(b. Access: Access to mobile home parks shall be designed to minimize congestion and hazards at the entrance or exit and allow free movement of traffic on adjacent streets. The entrance road connecting the park streets with a public street or road shall have a minimum road pavement width of 34 feet where parking is permitted on both sides, or a minimum road pavement width of 27 feet where parking is limited to one side. Where the primary entrance road is more than 100 feet long and does not provide access to abutting mobile home lots within such distance, the minimum road pavement width may be 24 feet, provided parking is prohibited at both sides.)

(c. Internal Streets: Surfaced roadways shall be of adequate width to accommodate anticipated traffic, and in any case shall meet the following minimum requirements:

(1. All streets, except minor streets ..... 24 feet
(2. Minor streets, no parking ..... 18 feet
(Acceptable only if less than 500 feet long and serving less than 25 mobile homes or of any length if one-way and providing access to abutting mobile home lots on one side only.)
(3. Dead end streets shall be limited in length to ..... 1,000 feet
and shall be provided at the closed end with a turn-around having an outside roadway diameter of at least 60 feet.)

(d. Required Illumination of Park Street Systems: All parks shall be furnished with lighting units so spaced and equipped with luminaires placed at such mounting heights as will provide the following average maintained levels of illumination for the safe movement of pedestrians and vehicles at night:

(1. All parts of the park street systems: 0.6 footcandle, with a minimum of 0.1 footcandle.

(2. Potentially hazardous locations, such as major street intersections and steps or stepped ramps: individually illuminated, with a minimum of 0.3 footcandle.)

(e. Street Construction and Design Standards:

(1. Pavement: All streets shall be provided with a smooth, hard and dense surface which shall be durable and well drained under normal use and weather conditions. Pavement edges shall be protected to prevent raveling of the wearing surface and shifting of the pavement base. Street surfaces shall be maintained free of cracks, holes and other hazards.)

(2. Grades: Grades of all streets shall be sufficient to insure adequate surface

drainage, but shall be not more than eight percent. Short runs with a maximum grade of 12 percent may be permitted, provided traffic safety is assured by appropriate paving, adequate leveling areas and avoidance of lateral curves.)

(3. Intersections: Within 100 feet of an intersection, streets shall be at approximately right angles. A distance of at least 150 feet shall be maintained between center lines of offset intersecting streets. Intersections of more than two streets at one point shall be avoided.)

((Park Street System

((a. General Requirements: All parking areas shall be provided with safe and convenient vehicular access from abutting public streets or roads to each trailer space. Alignment and gradient shall be properly adapted to topography. Surfacing and maintenance shall provide a smooth, hard and dense surface which shall be well drained.))

((b. Access: Access to travel trailer parking areas shall be designed to minimize congestion and hazards at their entrance or exit and allow free movement of traffic on adjacent streets. All traffic into or out of the parking areas shall be through such entrances and exits.))

((c. Internal Streets: Surfaced roadways shall be of adequate width to accommodate anticipated traffic and in any case shall meet the following minimum requirements:

One-way, no parking	11 feet
(Acceptable only if less than 500 feet total length and serving less than 25 trailer spaces.)	
One-way, parking on one side only, or	
Two-way, no parking	18 feet
(Acceptable only if serving less than 50 trailer spaces.)	
Two-way, no parking	24 feet
Two-way, parking on one side only	27 feet
Two-way, parking on both sides	34 feet

((d. Off-Street Parking and Maneuvering Space: Each travel trailer parking area shall provide sufficient parking and maneuvering space so that the parking, loading or maneuvering of trailers incidental to parking shall not necessitate the use of any public street, sidewalk or right-of-way or any private grounds not part of the travel trailer parking area.))

(Required Off-Street Parking Areas

(a. Off-street parking areas shall be provided in all mobile home parks for the use of park occupants and guests. Such areas shall be furnished at the rate of at least 1.25 car spaces for each mobile home lot.)

(b. Required car parking spaces shall be so located as to provide convenient access to the mobile home, but shall not exceed a distance of 200 feet from the mobile home that it is intended to serve.)

(Walks

(a. General Requirements: All parks shall be provided with safe, convenient, all season pedestrian access of adequate width for intended use, durable and convenient to maintain, between individual mobile homes, the park streets, and all community facilities provided for park residents. Sudden changes in alignment and gradient shall be avoided.)

(b. Common Walk System: A common walk system shall be provided and maintained between locations where pedestrian traffic is concentrated. Such common walks shall have a minimum width of three and one-half feet.)

(c. Individual Walks: All mobile home stands shall be connected to common walks, to paved streets, or to paved driveways or parking spaces connecting to a paved street. Such individual walks shall have a minimum width of two feet.)

(Mobile Home Stands

(The area of the mobile home stand shall provide an adequate foundation for the placement and tie-down of the mobile home, thereby securing the superstructure against uplift, sliding, rotation and overturning.)

(a. The mobile home stand shall not heave, shift or settle unevenly under the weight of the mobile home due to frost action, inadequate drainage, vibration or other forces acting on the superstructure.)

(b. The mobile home stand shall be provided with anchors and tie-downs such as cast-in-place concrete "dead men," eyelets imbedded in concrete foundations or runways, screw augers, arrowhead anchors, or other devices securing the stability of the mobile home.)

(c. Anchors and tie-downs shall be placed at least at each corner of the mobile home stand and each shall be able to sustain a minimum tensile strength of 2,800 pounds.)

Section 8: Water Supply

General Requirements

An accessible, adequate, safe, and potable supply of water shall be provided in each mobile home park or travel trailer parking area. Where a public supply of water of satisfactory quantity, quality, and pressure is available, connection shall be made thereto and its supply used exclusively. When a satisfactory public water supply is not available, a private water supply system may be developed and used as approved by the health authority.

Source of Supply

(a. The water supply shall be capable of supplying a minimum of 150 gallons per day per mobile home.)

((b. The water supply shall be capable of supplying 50 gallons per space per day for all spaces lacking individual water connections and 100 gallons per space per day for all spaces provided with individual water connections.))

c. Every well or suction line of the water supply system shall be located and constructed in such a manner that neither underground nor surface contamination will reach the water supply from any source. The following minimum distances between wells and various sources of contamination shall be required.

Contamination Sources	Well or Suction Line (Distance in Feet)
Building Sewer	50
Septic Tank	50
Disposal Field	100
Seepage Pit	100
Dry Well	50
Cesspool	150

d. No well-casings, pumping machinery or suction pipes shall be placed in any pit, room or space extending below ground level nor in any room or space above ground which is walled in or otherwise enclosed unless such rooms, whether above or below ground, have free drainage by gravity to the surface of the ground.

e. The treatment of a private water supply shall be in accordance with applicable laws and regulations.

Water Storage Facilities

All water storage reservoirs shall be covered, watertight and constructed of impervious material. Overflows and vents of such reservoirs shall be effectively screened. Manholes shall be constructed with overlapping covers, so as to prevent the entrance of contaminated material. Reservoir overflow pipes shall discharge through an acceptable air gap.

Water Distribution System

a. The water supply system of the mobile home park or travel trailer parking area shall be connected by pipes to all mobile homes or travel trailers, buildings, and other facilities requiring water.

b. All water piping, fixtures and other equipment shall be constructed and maintained in accordance with state and local regulations and requirements and shall be of a type and in locations approved by the health authority.

c. The water piping system shall not be connected with non-potable or questionable water supplies and shall be protected against the hazards of backflow or back siphonage.

d. The system shall be so designed and maintained as to provide a pressure of not less than 20 pounds per square inch, under normal operating conditions at service buildings and other locations requiring potable water supply.

(Individual Water-Riser Pipes and Connections

(a. Individual water riser pipes shall be located within the confined area of the mobile home stand at a point where the water connection will approximate a vertical position.)

(b. Water riser pipes shall extend at least four inches above ground elevation. The pipe shall be at least three-quarter inch. The water outlet shall be capped when a mobile home does not occupy the lot.)

(c. Adequate provisions shall be made to prevent freezing of service lines, valves and riser pipes and to protect risers from heaving and thawing actions of ground during freezing weather. Surface drainage shall be diverted from the location of the riser pipe.)

(d. A shutoff valve below the frost line shall be provided near the water riser pipe on each mobile home lot.)

(e. Underground stop and waste valves shall not be installed on any water service.)

((Watering Stations

((Each travel trailer parking area shall be provided with one or more easily accessible water supply outlets for filling trailer water storage tanks. Such water supply outlets shall consist of at least a water hydrant and the necessary appurtenances and shall be protected against the hazards of backflow and back siphonage.))

((Individual Water Connections

If facilities for individual water service connections be provided, the following requirements shall apply:

((a. Riser pipes provided for individual water-service connections shall be so located and constructed that they will not be damaged by the parking of travel trailers.))

((b. Water riser pipes shall extend at least four inches above ground elevation. The pipe size shall be three-quarter inch.))

((c. Adequate provisions shall be made to prevent freezing of service lines, valves and riser pipes.))

((d. Underground stop and waste valves shall not be installed on any water service.))

((e. Valves shall be provided near the outlet of each water service connection. They shall be turned off and the outlets capped or plugged when not in use.))

Section 9: Sewage Disposal

General Requirements

An adequate and safe sewerage system shall be provided in all mobile home parks or travel trailer parking areas for conveying and disposing of all sewage. Such system shall be designed,

constructed and maintained in accordance with state and local laws.

((Sanitary Station

((a. A sanitary station shall be provided consisting of at least a trapped four inch sewer riser pipe, connected to the travel trailer parking area sewerage system, surrounded at the inlet end by a concrete apron sloped to the drain, and provided with a suitable hinged cover; and a water outlet, with the necessary appurtenances, connected to the parking area water supply system to permit periodic washdown of the immediate adjacent areas.))

((b. Each travel trailer parking area shall be provided with a sanitary station in the ratio of one for every 100 trailer spaces or fractional part thereof.))

((c. Sanitary stations shall be screened from other activities by visual barriers such as fences, walls or natural growth and shall be separated from any trailer space by a distance of at least 50 feet.))

Sewer Lines

All sewer lines shall be located in trenches of sufficient depth to be free of breakage from traffic or other movements and shall be separated from the park water supply system at a safe distance. Sewers shall be at a grade which will insure a velocity of two feet per second when flowing full. All sewer lines shall be constructed of materials approved by the health authority, shall be adequately vented, and shall have watertight joints.

Individual Sewer Connections

a. The sewer riser pipe shall have at least a four inch diameter, shall be trapped below the ground surface and shall be so located on the mobile home lot or trailer space that the sewer connection to the mobile home or trailer drain outlet will approximate a vertical position.

b. The sewer connection (see definition) shall have a nominal inside diameter of at least three inches, and the slope of any portion thereof shall be at least one-fourth inch per foot. The sewer connection shall consist of one pipe line only without any branch fittings. All joints shall be watertight.

c. All materials used for sewer connections shall be semirigid, corrosive resistant, nonabsorbent and durable. The inner surface shall be smooth.

d. Provision shall be made for plugging the sewer riser pipe when a mobile home or travel trailer does not occupy the lot. Surface drainage shall be diverted away from the riser. The rim of the riser pipe shall extend at least four inches above ground elevation.

((Sink Wastes

((No liquid wastes from sinks shall be charged onto or allowed to accumulate on the ground surface.))

Sewage Treatment and/or Discharge

Where the sewer lines of the mobile home park or travel trailer parking area are not connected to a public sewer, all proposed sewage disposal facilities shall be approved by the health authority prior to construction. Effluents from sewage treatment facilities shall not be discharged into any waters of the State except with prior approval of the health authority.

Section 10: Electrical Distribution System

Every park shall contain an electrical wiring system consisting of wiring, fixtures, equipment and appurtenances which shall be installed and maintained in accordance with applicable codes and regulations governing such systems. (This applies to travel trailer parking areas, if need be.)

Power Distribution Lines

a. Main power lines not located underground shall be suspended at least 18 feet above the ground. There shall be a minimum horizontal clearance of three feet between overhead wiring and any mobile home, travel trailer, service building or other structure.

b. All direct burial conductors or cable shall be buried at least 18 inches below the ground surface and shall be insulated and specially designed for the purpose. Such conductors shall be located not less than one foot radial distance from water, sewer, gas or communication lines.

Individual Electrical Connections

(a. Each mobile home lot shall be provided with an approved disconnecting device and overcurrent protective equipment. The minimum service per outlet shall be 120/240 volts AC, 50 amperes.)

((b. If individual trailer spaces be connected to the electrical wiring system, an approved type of disconnecting device and overcurrent protective equipment shall be provided. The service per outlet shall be 120 volts AC, 15 amperes and/or 30 amperes.))

c. Outlet receptacles at each mobile home or travel trailer stand shall be located not more than 25 feet from the overcurrent protective devices in the mobile home or travel trailer and a three-pole, four-wire grounding type shall be used. Receptacles shall be of weatherproof construction and configurations shall be in accordance with American Standard Outlet Receptacle C-73.1.

d. The mobile home or travel trailer shall be connected to the outlet receptacle by an approved type of flexible cable with connectors and a male attachment plug.

(e. Where the calculated load of the mobile home is more than 50 amperes either a second outlet receptacle shall be installed or electrical service shall be provided by means of permanently installed conductors.)

Required Grounding

All exposed noncurrent carrying metal parts of mobile home or travel trailers and all other equipment shall be grounded by means of an approved grounding conductor with branch circuit conductors or other approved method of grounded metallic wiring. The neutral conductor shall not be used as an equipment ground for mobile homes or travel trailers or other equipment.

Section 11: Service Building and other Community Service Facilities

General

The requirements of this Section shall apply to service buildings, recreation buildings and other community service facilities such as: a) Management offices, repair shops and storage areas; b) Sanitary facilities; c) Laundry facilities; d) Indoor recreation areas; e) Commercial uses supplying essential goods or services for the exclusive use of park occupants.

(Required Community Sanitary Facilities

(Every park shall be provided with the following emergency sanitary facilities:

(For each 100 mobile home lots, or fractional part thereof, there shall be one flush toilet and one lavatory for each sex; the building containing such emergency sanitary facilities shall be accessible to all mobile homes.)

((Service Building

((a. A central service building containing the necessary toilet and other plumbing fixtures specified shall be provided in travel trailer parking areas which provide parking spaces for dependent trailers. Service buildings shall be conveniently located within a radius of approximately 300 feet to the spaces to be served.))

((b. Where a travel trailer parking area is designed for and exclusively limited to use by self-contained trailers, only the following minimum emergency sanitary facilities shall be required: for each 100 trailer spaces, or fractional part thereof, there shall be one flush toilet and one lavatory for each sex.)) For dependent travel trailers see following table.

No. of Parking Spaces[a]	Toilets Men	Toilets Women	Urinals Men	Lavatories Men	Lavatories Women	Showers Men	Showers Women	Other Fixtures[b]
1-15	1	1	1	1	1	1	1	1 Service sink with a flushing rim[c]
16-30	1	2	1	2	2	1	1	
31-45	2	2	1	3	3	1	1	
46-60	2	3	2	3	3	2	2	
61-80	3	4	2	4	4	2	2	
81-100	3	4	2	4	4	3	3	

For parking areas having more than 100 travel trailer spaces there shall be provided: 1 additional toilet and lavatory for each sex per each additional 30 travel trailer spaces; 1 additional shower for each sex per each additional 40 travel spaces; and 1 additional men's urinal per each additional 100 travel trailer spaces.

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[a] Parking spaces for dependent trailers

[b] Additional fixtures including laundry trays, clothes washing machines (one for every 30

[c] A service sink with a flushing rim shall be provided for disposal of liquid wastes unless a sanitary station is conveniently accessible for this purpose.

((c. When a travel trailer parking area requiring a service building is operated in connection with a resort or other business establishment, the number of sanitary facilities for such business establishment shall be in excess of those required by the schedule for trailer spaces and shall be based on the total number of persons using such facilities.))

((d. Exemption: Any person desiring to furnish temporary facilities for accommodating a travel trailer rally, or other group of trailers assembled for the purpose of traveling together, shall make application for such activity to the health authority. The requirements for a service building and other sanitary and physical facilities may be waived by the health authority on the determination that public health will not be endangered; but the location of the site, the facilities which are provided, and the method of conducting such rally shall be acceptable to the health authority before a special license shall be issued specifying the location of the site. The period of operation shall not exceed ten days.))

Structural Requirements for Buildings

a. All portions of the structure shall be properly protected from damage by ordinary uses and by decay, corrosion, termites and other destructive elements. Exterior portions shall be of such materials and be so constructed and protected as to prevent entrance or penetration of moisture and weather.

b. All rooms containing sanitary or laundry facilities shall:

1. Have sound resistant walls extending to the ceiling between male and female sanitary facilities. Walls and partitions around showers, bathtubs, lavatories and other plumbing fixtures shall be constructed of dense, nonabsorbent, waterproof material or covered with moisture resistant material.

2. Have at least one window or skylight facing directly to the outdoors. The minimum aggregate gross area of windows for each required room shall be not less than 10 percent of the floor area served by them.

3. Have at least one window which can be easily opened, or a mechanical device which will adequately ventilate the room.

c. Toilets shall be located in separate compartments equipped with self-closing doors. Shower stalls shall be of the individual type. The rooms shall be screened to prevent direct view of the interior when the exterior doors are open.

d. Illumination levels shall be maintained as follows:
   1. General seeing tasks - five footcandles;
   2. Laundry room work area - 40 footcandles;
   3. Toilet room, in front of mirrors - 40 footcandles.

e. Hot and cold water shall be furnished to every lavatory, sink, bathtub, shower and laundry fixture, and cold water shall be furnished to every water closet and urinal.

Barbecue Pits, Fireplaces, Stoves and Incinerators

Cooking shelters, barbecue pits, fireplaces, woodburning stoves and incinerators shall be so located, constructed, maintained and used as to minimize fire hazards and smoke nuisance both on the property on which used and on neighboring property. No open fire shall be permitted except in facilities provided. No open fire shall be left unattended. No fuel shall be used and no material burned which emits dense smoke or objectionable odors.

Section 12: Refuse Handling

The storage, collection and disposal of refuse in the mobile home park or travel trailer parking area shall be so conducted as to create no health hazards, rodent harborage, insect breeding areas, accident or fire hazards or air pollution.

All refuse shall be stored in flytight, watertight, rodentproof containers, which shall be located not more than 150 feet from any mobile home or travel trailer lot. Containers shall be provided in sufficient number and capacity to properly store all refuse.

Refuse collection stands shall be provided for all refuse containers. Such container stands shall be so designed as to prevent containers from being tipped, to minimize spillage and container deterioration and to facilitate cleaning around them.

All refuse containing garbage shall be collected at least twice weekly. Where suitable collection service is not available from municipal or private agencies, the mobile home park or travel trailer parking area operator shall provide this service. All refuse shall be collected and transported in covered vehicles or covered containers.

Where municipal or private disposal service is not available, the mobile home park or travel trailer parking area operator shall dispose of the refuse by incineration or transporting to a disposal site approved by the health authority.

Refuse incinerators shall be constructed in accordance with engineering plans and specifications which shall be reviewed and approved by the health authority or other authority having jurisdiction.

Incinerators shall be operated only when attended by some person specifically authorized by the owner or operator of the mobile home park or travel trailer parking area.

Section 13: Insect and Rodent Control

Grounds, buildings and structures shall be maintained free of insect and rodent harborage and infestation. Extermination methods and other measures to control insects and rodents shall conform with the requirements of the health authority.

Parks shall be maintained free of accumulations of debris which may provide rodent harborage or breeding places for flies, mosquitoes and other pests.

Storage areas shall be so maintained as to prevent rodent harborage; lumber, pipe and other building material shall be stored at least one foot above the ground.

Where the potential for insect and rodent infestation exists, all exterior openings in or beneath any structure shall be appropriately screened with wire mesh or other suitable materials.

The growth of brush, weeds and grass shall be controlled to prevent harborage of ticks, chiggers and other noxious insects. Parks or areas shall be so maintained as to prevent the

growth of ragweed, poison ivy, poison oak, poison sumac and other noxious weeds considered detrimental to health. Open areas shall be maintained free of heavy undergrowth of any description.

Section 14: Fuel Supply and Storage

(Natural Gas System

(a. Natural gas piping systems shall be installed and maintained in accordance with applicable codes and regulations governing such systems.)

(b. Each mobile home lot provided with piped gas shall have an approved manual shutoff valve installed upstream of the gas outlet. The outlet shall be equipped with an approved cap to prevent accidental discharge of gas when the outlet is not in use.)

Liquified Petroleum Gas Systems

(a. Liquified petroleum gas systems shall be installed and maintained in accordance with applicable codes and regulation governing such systems.)

(b. Systems shall be provided with safety devices to relieve excessive pressures and shall be arranged so that the discharge terminates at a safe location.)

(c. Systems shall have at least one accessible means for shutting off gas. Such means shall be located outside the mobile home and shall be maintained in effective operating condition.)

(d. All LPG piping outside of the mobile homes shall be well supported and protected against mechanical injury. Undiluted liquified petroleum gas in liquid form shall not be conveyed through piping equipment and systems in mobile homes.)

e. Liquified petroleum gas containers installed on a mobile home lot or travel trailer space shall be securely but not permanently fastened to prevent accidental overturning. Such containers shall not be less than 12 nor more than 60 U.S. gallons gross capacity.

f. No liquified petroleum gas vessel shall be stored or located inside or beneath any storage cabinet, carport, mobile home, travel trailer, or any other structure, unless such installations be approved by the health authority.

Fuel Oil Supply Systems

(a. All fuel oil supply systems shall be installed and maintained in accordance with applicable codes and regulations governing such systems.)

(b. All piping from outside fuel storage tanks or cylinders to mobile homes shall be permanently installed and securely fastened in place.)

c. All fuel oil storage tanks or cylinders shall be securely fastened in place and shall not be located inside or beneath any mobile home or travel trailer or less than five feet from any mobile home or travel trailer exit.

d. Storage tanks located in areas subject to traffic shall be protected aginst physical damage.

Section 15. Fire Protection

The mobile home or travel trailer parking areas shall be subject to the rules and regulations of the (name of municipality) fire prevention authority.

Mobile home parks or travel trailer parking areas shall be kept free of litter, rubbish and other flammable materials.

Portable fire extinguishers of a type approved by the fire prevention authority shall be kept in service buildings and at all other locations designated by such fire prevention authority and

shall be maintained in good operating condition.

Fires shall be made only in stoves, incinerators and other equipment intended for such purposes.

a. Fire hydrants shall be installed if the park or area water supply system be capable to serve them in accordance with the following requirements:

1. The water supply system shall permit the operation of minimum of two one and one-half inch hose streams.

2. Each of two nozzles, held four feet above the ground, shall deliver at least 75 gallons of water per minute at a flowing pressure of at least 30 pounds per square inch at the highest elevation point of the park or area.

b. Fire hydrants, if provided, shall be located within 500 feet of any mobile home, travel trailer, service building or other structure in the park or area.

Section 16: Miscellaneous Requirements

Responsibilities of the Park Management

a. The person to whom a license for a mobile home park or travel trailer parking area is issued shall operate the park in compliance with this Ordinance and regulations issued hereunder and shall provide adequate supervision to maintain the park or area, its facilities and equipment in good repair and in a clean and sanitary condition.

b. The park or area management shall notify park or area occupants of all applicable provisions of this Ordinance and inform them of their duties and responsibilities under this Ordinance and regulations issued hereunder.

c. The park or area management shall supervise the placement of each mobile home or travel trailer stand which includes securing its stability and installing all utility connections.

d. The park or area management shall maintain a register containing the names of all park or area occupants. Such register shall be available to any authorized person inspecting the park or area.

e. The park or area management shall notify the health authority immediately of any suspected communicable or contagious disease within the park or area.

Responsibilities of Park or Area Occupants

a. The park or area occupant shall comply with all applicable requirements of this Ordinance and regulations issued hereunder and shall maintain his mobile home lot or travel trailer parking space, its facilities and equipment in good repair and in a clean and sanitary condition.

b. The park or area occupant shall be responsible for proper placement of his mobile home or travel trailer on its stand and proper installation of all utility connections in accordance with the instructions of the park management.

c. No owner or person in charge of a dog, cat or other pet animal shall permit it to run at large or to commit any nuisance within the limits of any mobile home lot or travel trailer parking space.

Restrictions on Occupancy

A mobile home or travel trailer shall not be occupied for dwelling purpose unless it be properly placed on a stand and connected to water, sewerage and electrical utilities.

Section 17: Penalties

Any person who violates any provision of this Ordinance shall upon conviction be punished by a fine of not less than ..... dollars nor more than ..... dollars; and each day's failure of compliance with any such provision shall constitute a separate violation.

Section 18: Conflict of Ordinances: Effect of Partial Invalidity

In any case where a provision of this Ordinance is found to be in conflict with a provision of

any other ordinance or code of this (name of municipality) existing on the effective date of this Ordinance, the provision which, in the judgment of the health authority, establishes the higher standard for the promotion and protection of the health and safety of the people shall prevail. In any case where a provision of this Ordinance is found to be in conflict with a provision of any other ordinance or code of this (name of municipality) existing on the effective date of this Ordinance which establishes a lower standard for the promotion and protection of the health and safety of the people, the provisions of this Ordinance shall be deemed to prevail, and such other ordinances or codes are hereby declared to be repealed to the extent that they may be found in conflict with this Ordinance.

If any section, subsection, paragraph, sentence, clause or phrase of this Ordinance shall be declared invalid for any reason whatsoever, such decision shall not affect the remaining portions of this Ordinance which shall remain in full force and effect; and to this end the provisions of this Ordinance are hereby declared to be severable.

Section 19: Effective Date[1]

This Ordinance shall be effective on and after the ..... day of ....., 19.....

1. In many states a local ordinance cannot become effective until it has been published or until a specific period of time after adoption has elapsed, etc. Even in the absence of such requirements, however, it will probably be considered advisable to prescribe an effective date which is at least 30 to 60 days later than the date of adoption of this Ordinance to give ample time for compliance.

Chapter XXVIII

School Sanitation,* Lighting, and Air-Conditioning

General sanitation in the school is a field that has been neglected. This, of course, is not necessarily the doings of the sanitarian. There are a number of factors involved in the resulting neglect. Be that as it may, the time has come to make up for lost time. As in many other phases of environmental hygiene, the functions belong both to the sanitarian and the public health engineer. No small part should be played by the architect as the designer of school structures, and those administrators who are the responsible heads of schools. Standards for the environmental hygiene of schools have been fairly well developed. Those pertaining to water supply and drinking facilities, food handling, excreta and refuse disposal, and swimming pools should be well known to the sanitarian since they are routine for him in many other phases of his activity. The principles of lighting, heating, ventilation and safety are phases of hygiene which, although having special characteristics of application in relation to the school, should also be known by the sanitarian from many of his other activities. The sanitarian should know how to make a sanitary survey of a school and be able to evaluate and interpret the results to the responsible head of the school. He should be watchful for new school construction or alteration of existing buildings in order to assure the community that the plans have been reviewed by the public health engineer and that the contractor is conforming to those plans. The operation of the school lunch rooms should be his special concern, and he should be able to aid the teachers in organizing their educational plans for teaching environmental hygiene.

The school holds an important place in health work because:

1) Children between the ages of six and fourteen spend about half of their wakened hours in schools. Besides the fact that many pre-school children attend kindergartens, millions of children attend high schools and colleges.

2) The school is in the strategic position for teaching the tenets of personal and community hygiene to a very susceptible group.

3) The close contact of pupils with one another, makes it necessary to take all possible hygienic precautions against the spread of epidemic diseases.

4) The demonstration of safe environmental hygiene to young minds, and their participation in sanitary living is the best education to the people of the next generation of adult citizens.

5) The school children are an important section of the population which is under regular surveillance for disease emergence. Preventing diseases among school children aids in prevention of spread of diseases to the smaller children in the homes whose immunity and vital strength are less developed.

Unfortunately the subject of school sanitation makes a serious sanitarian blush with embarrassment. We have schools in our country which are models of perfection, but these are, lamentably, too few. A large number of our urban schools are old and delapidated, but a much larger proportion of our rural schools are unfit for housing children. Actually, some schools are such primitive abodes and some school authorities are so lacking in funds that the level of sanitary measures which can be enforced is scarcely higher than for temporary camps. The increase in crowding has further deteriorated school hygiene.

In 1949 there were about 240, 000 elementary and secondary schools attended by over 29, 000, 000 children in the United States. Twenty years ago 12, 300 school buildings were actually condemned by public officials, but this figure does not represent all that should have been condemned. In 1935, there were about 20, 000 school buildings that were constructed before 1870, and 1/3 of all buildings were constructed between 1870 and 1899. In the past 30 years, there were only 2 periods of increased impetus in school building construction, i. e., around the 1928 period and during the latter part of 1930. At no time has any effort been adequate to even come close to solving the school building problem. At present there are signs that another school construction period may be beginning.

* Good reference: Environmental Engineering for the School: A Manual of Recommended Practice, U. S. Department of Health, Education, and Welfare, Public Health Service Bulletin, No. 856, 1961.

One needs but make a sanitary survey of his town, county, or state if further proof needs to be collected to dispell ones cloud of incredulity. With still a large number of counties in the United States lacking full time public health supervision, one will find that annual sanitary inspection of schools by competent sanitarians is a luxury that many places lack.

The typical school sanitation program as it is actually being practiced is very limited in scope if one contemplates the possibilities of what might be done. In many places, scarcely more than water supply and excreta disposal sanitation has composed the regular program. The development of the school lunch room program has stimulated action in that direction. But those phases of the sanitary program which affect the physiological and psychological growth and development of the school child have scarcely been touched.

Sanitary standards for school environment differ greatly from state to state. In every state, the department of public instruction is the official agency charged by law for the control of educational facilities. In most states the departments of education and health have developed a working relationship to coordinate efforts towards raising the level of the school environment. Several organizations have already begun to study and set standards for school environment, such as the National Council on School House Construction, and the American Council on Education Studies. In May 1947, the Committee on School Sanitation of the Engineering Section of the American Public Health Association was organized. This was a belated step, but a welcome one.

The latter Committee has developed the following list of broad topics that are important in inspecting schools:

Group I	Group II	Group III
Site	Water Supply	Sewage Disposal
Structure	Drinking Fountains	Refuse Disposal
Rooms	Food Equipment	Source of food
Seating	Showers & Locker Rooms	Handling Procedures of Hot Lunch Program
Heating and Ventilation	Swimming Pools	Housekeeping
Lighting	Handwashing facilities	
Safety	Toilet Facilities	

For most of these items, there are available uniform standards with which the authorities generally agree. There is now a need for the adoption of these standards by health and school authorities in order to bring some order and uniformity in the practice of school sanitation. The subsequent discussion will be organized on the basis of the items listed in the above 3 groups. These items may also be used for the development of a grading system for schools.

The above committee found several areas where agreement of standards is still not general. These areas concern:

1) Window and mechanical ventilation, and air conditioning.
2) The amount of water consumed per pupil.
3) The amount of septic tank capacity to provide per pupil.
4) The amount of floor space to be provided.
5) Satisfactory methods of dishwashing and food handling in rural schools.
6) Suitable methods of treating and covering floors.

It is evident, of course, that the problems of school sanitation will not be the same in urban as in the rural area, nor in the small school as in the large school. Therefore, the problems of school sanitation divide themselves into 4 classifications.

1) The one or two room rural school which produces its own water supply and provides its own sewage disposal facilities on the school site and is constructed with or without a basement.
2) The consolidated school, located in a rural area which has its own water supply and sewage disposal system.
3) The grade school or high school unit of the average urban community.
4) The large urban school or college which has groups of buildings and grounds.

The following discussion will make no attempt to separate out the school sanitation problems into these four categories, but the sanitarian must be able to use his judgement to make such distinctions in practice.

Let us not forget that the school is a place where the pupils may learn a great deal about environmental and personal hygiene, and therefore the sanitary administrative procedures and techniques for making the school a better place in which to live should be planned around the participation of the pupils themselves.

Site

Suggested criteria for selection of school site:

1) Should not be on a steep hill or slope but in position to receive the maximum amount of sunlight.

2) Size of area should be large enough to accommodate building, expansion, and recreational area.

3) Must not be adjacent to railways, broken by highways nor directly on a main highway, nor near factories or other property where unnecessary noises, odors, dust, soot, gases or other disturbances would be likely to interfere with the school program.

4) Should be accessible to area served, i. e., near bus lines, paved roads, or streets as now developed with due regard to future development of community.

5) Must be easily drainable and suitable for recreational facilities.

The playgrounds should be:

1) At least reasonably level, so drained as to secure dryness a maximum of days in the year, not completely shaded.

2) Clear of stumps, rocks, gullies, trash, manure, weeds, or other obstructions which render the playground unsafe for play; have neat trash receptacles with cover (an ordinary metal barrel may be used.)

3) Fitted out with relatively safe equipment and in such condition that accidents cannot occur from faults of the apparatus itself.

4) Provided with "all weather walks" which may be made of any suitable material which will not become muddy in wet weather. Cement, gravel, cinders, etc., may be used. If gravel or other loose material be used, some provision should be made to keep the materials from scattering; either an outline or sunken walk-way should be made. The walk should be wide enough to permit passing without stepping off. Monitors may be appointed for various playground responsibilities.

Structure Requirements

1) Orientation and construction in order to receive the maximum amount of natural light in the classrooms, and a satisfactory amount in corridors and along stairways. Adequate supplementary artificial lighting.

2) Healthful air conditions secured by effective heating and ventilation.

3) Planned to meet changing needs in the curriculum; and to serve community needs.

4) Adequate protection against fire and other life and health hazards.

5) Reduction of vertical travel.

6) Satisfactory acoustics.

7) Equipment, constructed and adjusted to meet the individual health needs of the school population.

8) Gymnasiums and playgrounds of adequate size and properly equipped.

9) Sanitary facilities correctly installed and of proper design.

10) Durable construction* but adaptable to modification and future extension.

11) Esthetic design.

12) Ample in size to prevent over-crowding for the present and for the relatively near future.

Rooms

The size of a classroom will depend mainly on:

1) The limitations on the number of pupils which can be handled effectively by the teacher.

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*In rural areas the foundation if often insecure. It should be tight and underpinned; this will make the floors more comfortable and save fuel. Rough rocks or slabs may be used for underpinning.

2) The air and floor space required to prevent overcrowding and maintain good ventilation.
3) The requirements for maintaining adequate natural lighting.
4) The requirements for maintaintaining good acoustical quality.
5) The space requirements for classroom equipment.

It is generally agreed that the floor space for classrooms should, if possible, not be less than 20 square feet per pupil, and even greater in modern structures, and that not more than 30 pupils should be assigned to each class for effective teaching and discipline. The classroom should not be long and narrow in order to prevent sound reverberations. It should be nearly square with windows on one side only. Other factors effecting the design of the classroom are discussed under "lighting","heating and ventilation" and "safety".

Cloakroom shelves should be provided (where lockers are not available) with individual sections separated by partitions, for lunch on top, and shelf hook for coats and caps directly beneath, with the owner's name or number on each section. A board, eight inches wide placed directly above the baseboard and under the wrap and lunch shelf has been found to be the most suitable place to store overshoes. Shelves should be kept clean. Monitors may be appointed to inspect the building daily, including the basement, lunch and wrap shelves.

The conditions of floors should be clean, smooth, firm, and in good repair. Ordinary sawdust may be saturated with waste cylinder oil or moistened with water and used as a sweeping compound. Tiletex floors should be mopped with water. A school room should not be dry swept. (See other instructions under Housekeeping).

Waste baskets should be solid metal. In poorer areas an ordinary lard or grease bucket obtained from a filling station may be used as a waste basket when painted.

First aid kit should be located in health room or teachers room. The teacher will do only the first dressing. Others should be done at home or by a physician. For content of Kit see subsequent regulations.

Blackboards should be of black or green dull finish. Boards and chalk tray should be kept clean with a soft moistened cloth to control dust. Cloth may be kept in a can to prevent its drying. A monitor may be appointed to keep the cloth moist, and to see that the boards are properly cleaned. Blackboards should never be placed between windows. Proper heights for blackboards are: primary grades, 24 inches; intermediate, 28 inches; upper grades, 32 inches.

Old blackboards which are to be refinished should be thoroughly sandpapered to remove all rough places, and should be given two coats of blackboard slaten.

Seating

Seats should be movable, adjustable and adaptable for varying the pattern of arranging the seats in the classroom to accommodate for such factors as left handedness, sight and hearing problems, and variation in teaching technique. The location of the child in the room should depend on his hearing and vision. Diagonal seating is sometime advisable to secure better lighting. Seats should be placed to allow daily cleaning of floor, and should not be placed close to stove or in draft. Ample space for books should be provided in desks or in lockers.

Correct size: Single seats should be of such height and depth that the child, when seated, can sit comfortably with feet resting firmly on the floor when the knees are at right angles. Primary tables are approved provided each child has 24 inches of table space, that no child sits at the ends, and that the table be so arranged that the light always shines on the table from one end. Good posture while seated should always be kept in mind. Back of seat should conform with natural contour of back of pupil. The school child is a growing child and therefore size of seat should be checked later in term.

Heating and Ventilation

Heating, ventilation, and air-conditioning are subjects so closely related in certain phases that their overlapping forces us to consider them together. The engineering aspects of these subjects will be left for the consideration of the engineer. We will look only into general principles and

the less technical phases.

Definitions: The definition of ventilation has been variously given. That subscribed to by the American Society of Heating and Ventilating Engineers is that ventilation is the process of supplying or removing air by natural or mechanical means to or from any space; it refers to quantity but not necessarily to quality of air. In this sense ventilation is a restricted term while air-conditioning is the general concept. The definition of ventilation bearing the general concept of quantity and quality of air is adhered to by some public health engineers, that is, that it is the art of maintaining in enclosed spaces an atmosphere that is comfortable and free from harmful factors. It really makes no difference which definition is adhered to, so long as one is consistent in terminology.

If we consider ventilation as a limited concept, then air-conditioning, conceived as the general concept is defined as including not only ventilation, but also simultaneously the control of temperature, humidity, air movement, and purity, that is, quality of air.

Composition of air:

Nitrogen	78.1 % by volume
Oxygen	20.9 % by volume
Carbon Dioxide	00.04% by volume
Argon	00.9 % by volume
Other gases	00.06% by volume

The results of human occupancy of enclosed spaces:

1) Oxygen slightly decreases due to respiration.
2) Carbon-dioxide slightly increases due to respiration.
3) Organic matter increases from nose, mouth, skin and clothing, usually detected as odor.
4) Temperature increases due to the giving off of body heat.
5) Humidity increases due to moisture from the lungs and perspiration from the skin.

Effect of heat on the body: When the external temperature rises, the small arteries and capillaries of the skin dilate bringing more blood to the surface of the body in order to cool the temperature of the body. This is a defense mechanism of the body to prevent overheating. The increased blood in the outer surface of the body causes a fall in blood pressure. At this point another defense mechanism of the body comes into play in order to maintain an adequate blood pressure. To do this, the heart rate increases and drives blood faster through the skin, so that more heat is given off from the body. The body can compensate in this manner up to a certain temperature, beyond which the defense mechanism is thrown out of order. When this happens, the heart rate will increase 14 to 20 beats per minute for each degree rise in temperature while the body is at rest, and 20 to 25 beats per minute for each degree rise while the person is standing. The respirations correspondingly increase; the metabolism increases also. When the heart rate rises around 130 beats per minute the person feels uncomfortable; when it reaches around 160 beats per minute the person feels very uncomfortable; if it rises higher, the heart and blood vessels fail to adjust themselves to the temperature and the blood pressure falls throwing the person into a condition known as heat exhaustion. Heat stroke or sun stroke is another condition caused by over heating and failure of the heat regulating center of the central nervous system to perform adequately, causing an excessive rise in temperature of the body. Heat cramps are due to muscular pain from loss of body salts through perspiration.

The amount of evaporation from the skin depends on:

1) Humidity in the air (increased humidity decreases evaporation of sweat.)
2) Temperature of the air (the higher the temperature the more moisture it can hold.)
3) Air movement (the greater the air movement the more evaporation.

Effects of cold on the body

1) Increase loss of body heat (within certain limits this is compensated by increased heat production of the body and decrease of blood circulation in skin.)
2) Decrease of heart rate.
3) Decrease skin temperature.

Relative Humidity Values Based on Dry-Bulb Temperature and Difference Between Dry-Bulb and Wet-Bulb Temperatures

Dry Bulb Temperature ° F.	DIFFERENCE BETWEEN DRY BULB AND WET BULB TEMPEPATURE ° F. AT 15 FT./SEC. MINIMUM AIR VELOCITY OVER WET BULB																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
43	92	85	77	70	63	55	48	42	35	28	21	14	8	1							
44	93	85	78	71	63	56	49	43	36	30	23	16	10	4							
45	93	86	78	71	64	57	51	44	38	31	25	18	12	6							
46	93	86	79	72	65	58	52	45	39	32	26	20	14	8	2						
47	93	86	79	72	66	59	53	46	40	34	28	22	16	10	5						
48	93	86	79	73	66	60	54	47	41	35	29	23	18	12	7	1					
49	93	86	80	73	67	61	54	48	42	36	31	25	19	14	9	3					
50	93	87	80	74	67	61	55	49	43	38	32	27	21	16	10	5	0				
51	94	87	81	75	68	62	56	50	45	39	34	28	23	17	12	7	2				
52	94	87	81	75	69	63	57	51	46	40	35	29	24	19	14	9	4				
53	94	87	81	75	69	63	58	52	47	41	36	31	26	20	16	10	6	1			
54	94	88	82	76	70	64	59	53	48	42	37	32	27	22	17	12	8	3			
55	94	88	82	76	70	65	59	54	49	43	38	33	28	23	19	14	9	5	0		
56	94	88	82	76	71	65	60	55	50	44	39	34	30	25	20	16	11	7	2		
57	94	88	82	77	71	66	61	55	50	45	40	35	31	26	22	17	13	8	4		
58	94	88	83	77	72	66	61	56	51	46	41	37	32	27	23	18	14	10	6	1	
59	94	89	83	78	72	67	62	57	52	47	42	38	33	29	24	20	16	11	7	3	
60	94	89	83	78	73	68	63	58	53	48	43	39	34	30	26	21	17	13	9	5	1
61	94	89	84	78	73	68	63	58	54	49	44	40	35	31	27	22	18	14	10	7	3
62	94	89	84	79	74	69	64	59	54	50	45	41	36	32	28	24	20	16	12	8	4
63	95	89	84	79	74	69	64	60	55	50	46	42	37	33	29	25	21	17	13	10	6
64	95	90	84	79	74	70	65	60	56	51	47	43	38	34	30	26	22	18	15	11	7
65	95	90	85	80	75	70	66	61	56	52	48	44	39	35	31	27	24	20	16	12	9
66	95	90	85	80	75	71	66	61	57	53	48	44	40	36	32	29	25	21	17	14	10
67	95	90	85	80	75	71	66	62	58	53	49	45	41	37	33	30	26	22	19	15	12
68	95	90	85	80	76	71	67	62	58	54	50	46	42	38	34	31	27	23	20	16	13
69	95	90	85	81	76	72	67	63	59	55	51	47	43	39	35	32	28	24	21	18	14
70	95	90	86	81	77	72	68	64	59	55	51	48	44	40	36	33	29	25	22	19	15
71	95	90	86	81	77	72	68	64	60	56	52	48	45	41	37	33	30	27	23	20	17
72	95	91	86	82	77	73	69	65	61	57	53	49	45	42	38	34	31	28	24	21	18
73	95	91	86	82	78	73	69	65	61	57	53	50	46	42	39	35	32	29	25	22	19
74	95	91	86	82	78	74	69	65	61	58	54	50	47	43	39	36	33	29	26	23	20
75	96	91	86	82	78	74	70	66	62	58	54	51	47	44	40	37	34	30	27	24	21
76	96	91	87	82	78	74	70	66	62	59	55	51	48	44	41	38	34	31	28	25	22
77	96	91	87	83	79	74	71	67	63	59	56	52	48	45	42	39	35	32	29	26	23
78	96	91	87	83	79	75	71	67	63	60	56	53	49	46	43	39	36	33	30	27	24
79	96	91	87	83	79	75	71	68	64	60	57	53	50	46	43	40	37	34	31	28	25
80	96	91	87	83	79	75	72	68	64	61	57	54	50	47	44	41	38	35	32	29	26
82	96	92	88	84	80	76	72	69	65	61	58	55	51	48	45	42	39	36	33	30	28
84	96	92	88	84	80	76	73	69	66	62	59	56	52	49	46	43	40	37	35	32	29
86	96	92	88	84	81	77	73	70	66	63	60	57	53	50	47	44	42	39	36	33	31
88	96	92	88	85	81	77	74	70	67	64	61	57	54	51	48	46	43	40	37	35	32
90	96	92	89	85	81	78	74	71	68	65	61	58	55	52	49	47	44	41	39	36	34

[1] Adopted from Technical & Engineering Data Section, Air Conditioning, Ventilation, Refrigeration, *Engineers Product File—1960.*

4) Increased blood pressure.
5) In extreme cases, unconsciousness and death will result.

Moderate variations in temperature are beneficial. Extreme heat or cold and extreme sudden changes of temperature appear to be harmful. Hygienic practices should include protection against or compensation for such extremes.

Carbon dioxide and oxygen: CO_2 can be increased to 2% (normal being .04 to 1%) without discomfort. It can rise to 3% before real discomfort. It takes about 40 to 50% CO_2 in the air to cause death. CO_2 never causes death in crowded conditions. In most crowded rooms there is usually not more than 1 to 2% of CO_2.

Discomforture of crowding is not due to decreased O_2 and increased CO_2, but to physical conditions of the air which cause a decreased ability of the body to cool itself. These factors are temperature, humidity, radiant heat, and air movement, and they are affected by:

1) Clothing - This prevents air movement at the surface of the skin, radiation of heat from the body, and cooling by evaporation.
2) Sex and age - Young boys and men prefer cooler atmosphere; women and older people prefer warmer atmosphere.
3) Activity - Physical exertion requires a lower effective temperature. (Effective temperature is an arbitrary index of the degree of warmth or cold felt by the human body in response to the combined effects of temperature, humidity and air movement.)
4) Season - The body is more comfortable when the effective temperature is:
63^{o} to 71^{o} F. in the winter,
65^{o} to 75^{o} F. in the summer.
5) Relative temperature of surrounding walls - cold walls increase radiation of heat from the body and raises the effective temperature for comfort.
6) Psychological - Fresh air "fiends" are uncomfortable with windows closed even when conditions are known to be optimum.

Modern Standards of Ventilation are Based on Comfort: Comfort is determined by:

1) Skin temperature - This is the most important factor. The skin nerve endings are stimulated to produce a feeling of comfort. Comfort temperatures of the skin range between 30^{o} and 35^{o} C. or between 82^{o} F. and 95^{o} F.
2) Stuffiness - This is probably due to conditions of the mucous membrane of the nose. Discomfort may be due to nasal membrane dryness or dilation of the blood vessels in the mucous membrane caused by heat.
3) Fluctuation of temperature and air movement.

The dry-bulb temperature is the temperature registered by an ordinary thermometer. The wet-bulb temperature is the lowest temperature which a water wetted body will attain when exposed to an air current. The wet bulb temperature is usually lower than the dry bulb temperature, since evaporation of the water causes a cooling process.

The effective temperature, as above explained, is an arbitrary index of the degree of warmth or cold felt by the human body in response to the combined effects of temperature, humidity, and air movement. The numerical value of the effective temperature for any given air condition is fixed by the temperature of moist-saturated air which at a velocity of 15 to 25 feet per minute, induces a sensation of warmth or cold like that of the given condition. Thus, any air condition has an effective temperature of 65^{o} F. when it induces a sensation of warmth like that experienced in practically still air 65^{o} F. and saturated with moisture.

The Kata-thermometer is used to determine the cooling characteristics of the air of a room. It is an alcohol thermometer.

The dry-bulb temperature of comfort is 68^{o} to 75^{o} F. for resting individuals; about 65^{o} F. for those doing light work, and around 60^{o} F. or less for those doing heavy work. These comfort temperatures are different in different countries due to the factor of acclimatization (which appears to depend on the nerves controlling the blood vessels and the fluidity and volume of the blood.)

The primary factors in air-conditioning are temperature, humidity, air-movement, and body odors.

Temperature - There are few experiments giving information relative to air-conditioning and health, although there appears to be some relation between excessive differences of temperatures of inside and outside buildings and common colds.

20° F. difference between the inside temperature and outside temperature is probably too great. 10° F. difference is probably much better except in excessive heat.

A person's mechanical efficiency (amount of work done related to amount of O_2 utilized) is not affected by high temperature, but the capacity (work done in a unit of time) is decreased about 28% in changing the temperature from 60° to 80° F. during a working period. This even occurs if the humidity be at the same time decreased. Accidents will increase on the job if the temperature and the humidity be inordinately increased.

Heat is transmitted in three ways: Conduction, convection, radiation.

When heat energy gradually diffuses through a mass of matter, passing from particle to particle from warmer toward the colder parts of the body, the process is called conduction. In this case, energy of motion is conceived as communicated from molecule to molecule progressively throughout the mass.

When heat is carried along by the motion of a stream of gas or liquid, the process is called convection. This is the most common method of heating buildings in the United States. Hot air, hot water, and steam heaters cause warm air currents to circulate in the building, i. e., by convection.

In the above two cases the transference of heat takes place in and through matter, but a hot body surrounded by a perfect vacuum may give out energy and warm neighboring objects. In this case the energy is transmitted by waves in the ether and the process is called radiation. Heating by radiation is by open grates, unjacketed stoves, electric heaters, gas burners, etc.

A method of heating which has not yet been much exploited, is the maintenance of warm walls in the presence of cool air. This method gives greater comfort since the presence of cool air is refreshing, yet the radiation from the walls maintains an adequate feeling of warmth of the body.

Air temperature	Wall temperature	Sensation as though air & walls were
68° F.	68.0° F.	68.0° F.
60° F.	79.0° F.	68.4° F.
55° F.	89.3° F.	70.3° F.
50° F.	101.0° F.	72.7° F.
45° F.	114.3° F.	75.8° F.

This shows how much air can be cooled if the surroundings be heated.

Humidity - There is no evidence that humidity has an effect on physical health, although it definitely has an effect on comfort and therefore behavior. It is possible that a low humidity may cause a drying of the nasal membrane with consequent predispostion to infection.

Relative humidity is the ratio between the amount of water vapor in the air at a particular temperature and the amount of water vapor that the air could hold at that temperature.

At 70° F., humidity plays little part in comfort, but when the temperature is high, increasing the humidity will decrease the ability of the body to lose heat, due to the decreased evaporation of perspiration from the skin. Therefore, at high temperatures it becomes important to maintain a moderately low humidity. When the temperature is low, an increased humidity will cause one to feel colder, due to the moisture in the clothing causing an increased conduction of heat away from the body. Therefore it is important to maintain a decreased humidity in cold weather if comfort be served. Where heat is furnished by a stove, moisture should be supplied by keeping

an open container of water on the stove. About 2 or 3 gallons of water should be evaporated daily in the average size classroom.

Air-movement - Air-movement is important in heat loss from body, because it changes the air in contact with the skin. Air-movement always increases heat loss from the body with one exception when the temperature of the air is the same as that of the body and the relative humidity is 100 percent.

Air-movement may have some effect on the pressure nerves in the skin, increasing muscle tone and producing a pleasant feeling.

Increasing air-movement is equivalent to lowering the temperature:
If the draft temperature be the same as room temperature then 40-80 ft./min. is comfortable.
" " " " " 1-1 1/2° F. below room temperature then 25 ft./min. is pleasant.
" " " " " 1 1/2-2° F. " " " " 40 ft./min. is uncomfortable
" " " " " more than 2° F. below room temperature then 50 ft./min. is very uncomfortable.

In this country, an air movement of 50-60 ft./minute is optimum if the draft temperature be the same as the room temperature.

The head is much more susceptible to comfort or discomfort due to air movement than the feet or ankles. When the feet temperature of air is as much as 2° F. lower than the head level temperature, a feeling of discomfort is usually produced. The maintenance of a temperature of 68° to 70° F. in a school room should be measured by keeping the thermometer on a stand, even with the pupils heads, and away from walls, stove, windows, and doors. The ankle temperature should be as close as possible to the head level temperature.

Body Odor and room space - Body odors and room space have no apparent effect on physical health directly, but may effect physical health indirectly by their effect on mental health.

The following figures are usually accepted as adequate for room space:
Floor space for 1st grade children - 15 sq. ft. per pupil.
" " " adult - 25 " " " person.

The recent trend toward larger school rooms would require adjusting upward the above figures and also the following figures:
Air space for 1st grade children - 200 cu. ft. per pupil.
" " " 2nd " " - 250 " " " "
" " " 6th " " - 310 " " " "
" " " adult - 200 cu. ft. per person.

Air supply used to be based on CO_2 standard as understood in 1895, and called for at least 30 cu. ft. of air per person per minute. This is considered today an illogical criterion on which to base a standard for air supply. The suffering from crowding is not due to lack of oxygen or excess of CO_2, but to excess of heat and humidity generated by the bodies of the people. The logical bases for air supply standard should be, then, heat regulation.

Relative figures for air supply are as follows:
For children
12 cu. ft./min./child where 470 cu. ft. of air space per child is allowed.
21 cu. ft./min./child where 200 cu. ft. of air space per child is allowed.
29 cu. ft./min./child where 100 cu. ft. of air space per child is allowed.

For adults
7 cu. ft./min./person where 500 cu. ft. of air space per person is allowed.
15 cu. ft./min./person where 200 cu. ft. of air space per person is allowed.
25 cu. ft./min./person where 100 cu. ft. of air space per person is allowed.

Air supply per square foot of floor space for:

1) School room - 2 cu. ft. per minute.
2) Gymasium - 1.5 cu. ft. per minute.
3) Assembly hall - 1.5 cu. ft. per minute.

Air supply should be changed in rooms at the rate of about 6 times per hour. Ordinarily, 10 cubic feet of fresh outside air per minute per person will keep odors out.

Air should be properly distributed throughout a room. This is accomplished by preventing any place in the room from having a CO_2 content of air more than 1 part in 1000.

Ventilation in schools. There is no difference in the health of school children whether they be subject to mechanical or non-mechanical methods of ventilation. The effect on the mental health, if any, has not been determined. There has been a general preference for window ventilation for schools so far as comfort is concerned.

Technique for window ventilation:

1) Radiator runs the entire length of window side of room.
2) Deflectors on windows extend one foot in height to prevent draft.
3) Radiator shields are placed in front of radiators to prevent excess of heat on children near the radiators.
4) Gravity exhaust is located on opposite side of room near the ceiling to carry off warm air.
5) Windows should open easily at the bottom and shades guided by ropes and pulley should be used to avoid shaking of shades by the inflow of air.
6) Adequate air space in rooms should be provided in accordance to standards.
7) Large thermometer with 68° F. clearly marked should be displayed on teacher's desk.

Window ventilation requires a lower room temperature (68° F.) than fan ventilation (70° F.) because fan ventilation produces greater air movement. Window ventilation at 68° F. produces less respiratory diseases than fan ventilation at 70° F.

In rural schools, jacket stoves are used for heating and distributing the air. This method works fairly well in an inadequate situation, but should be replaced by other methods more satisfactory when possible. When such stove is used, it should be placed near a window, and the door of the jacket should be kept closed.

No one type of ventilation is universally satisfactory:

1) Window ventilation alone is satisfactory for living rooms, sleeping rooms, hospital rooms, etc.
2) Window inlets with gravity exhausts are satisfactory for school rooms, ordinary offices, many factory workrooms, etc.
3) Fan ventilation is satisfactory for large crowded offices or workrooms, rooms with special heat sources present, auditoriums, crowded rooms with little heat loss through the walls and ceilings, etc. This type is used where windows cannot be opened or spaces are very large.
4) Modern air conditioning techniques are being developed for use in almost all circumstances. Their application is as yet not altogether satisfactory, but much is to be hoped for in the future from these techniques.

Carbon Monoxide - The increased use of natural and artificial gas for heating purposes has developed a hazard which has frequently resulted in deaths. The deaths may be due to leakage of the fuel gas itself, but the greater danger is the carbon monoxide (CO) which may be generated by faulty appliances. The danger is increased by the fact that CO is odorless and non-irritating. When breathed in, it first causes headache, weariness, dizziness, followed by nausea, vomiting and finally death. The symptoms are caused by the fact that the CO has a chemical affinity for the hemoglobin of the blood, thereby interfering with its normal oxygen-carbon-dioxide-carrying power. CO has an affinity for the hemoglobin, 300 times greater than O_2. CO is a common constituent of manufactured gas. It is produced by the incomplete combustion of any organic matter.

Water gas contains	38.0%	CO
Illuminating Gas "	24.9%	"
Producer Gas "	20.0%	"
Exhaust Gas "	6.3%	"
Coal Gas "	6.0%	"
Natural Gas "	0.4%	"

Natural gas leakage would not cause CO poisoning, but incomplete combustion of it would cause such poisoning.

Any place where gas of any kind is used for power, CO is produced. It is produced by pouring molten metal into molds, blasting, explosions, fires, compressors (where oil is used) etc.

A person can stand 1 part in 10,000 of CO in the air indefinitely. 4 parts per 10,000 is safe for 1 hour. If the concentration in the blood hemoglobin rises above 20%, dizziness and nausea set in. Higher concentrations produce acute symptoms and if not removed from the blood, the person may die.

Ventilation is becoming an important industrial hygiene problem due to the many gases and dusts produced in industry.

Basic Principles of Acoustics

In the design of school buildings attention should be paid to the control of noise, which is unwanted sound. Consideration should be given to the general sound pressure levels of the area in which the building is to be located, and the building should be so designed that classrooms are shielded against excessive noise levels. Interior acoustic treatment of classrooms and auditoriums should also be provided where required. Reduction of transmitted sound and control in an area of sound originating therein are different problems and require different solutions.

Public Health Reason

Excessive noise causes irritation, mental and emotional strain, distraction and inefficiency in school children, teachers and employees.

Satisfactory Practice

1. Acceptable Noise Levels: The highest level of noise in a school building which will not disturb the occupants is called the "acceptable noise level". Acceptable noise levels for various types of rooms are given in the following table.

Table 1

Acceptable Noise Levels in School Areas

Type of Room	Acceptable Noise Levels in Decibels
Classrooms	35 to 40
Cafeterias	50 to 55
School sites (outdoor noise levels)	Less than 70
Health rooms	Less than 45
Hearing test rooms	Less than 40
Music rooms	Less than 40

Interior noise levels of the order given above will not be attained unless care be exercised in the design and construction of the rooms involved.

2. Sources of Noise (External): External sources of noise are heavily traveled streets, railroad yards and tracks, airports, factories, playgrounds and low-flying planes. A reason for selecting a school site where the external noise level is not in excess of 70 decibels is that treatment of walls and windows to achieve reductions of more than 30 to 35 decibels is difficult

and costly.

3. Sources of Noise (Internal): Some internal noise sources are building machinery, air-conditioning equipment - including air-conditioning air outlets - children walking in classrooms and corridors, children playing in gymnasiums or using swimming pools and elevators. In order that such sources of noise may be controlled, it is necessary that the school building be planned so that walls and ceiling are utilized to absorb as much sound as possible without deadening effects; and to insure that special areas such as auditoriums are accoustically as well as structurally designed. It is important that shops, gymnasiums, auditoriums, band and choral practice rooms be located as far as possible from other teaching areas.

4. Acoustic Planning: Precision acoustic planning requires the services of acoustic consultants who should be retained either by school boards or the architect in charge of the school design project. It is possible in the design stage to specify types of wall and ceiling materials which will act as sound absorbers and properly proportion these areas so as to achieve an environment in which noise is controlled without making the area one in which an unnatural "deadness" is noticed.

The school authorities, however, can be aware of the general requirements for noise levels in the school building, and can require in the planning stage the levels which will be acceptable when the building is completed.

5. Acoustic Treatment: There are four general principles used in achieving acoustic control. The first is the control of the noise source. For example, noisy motors and fans may often be quieted by changing the coupling between them or by installing a better insulating device between the fans and the floor. The second is that of separating the school building as far as possible from noise sources. A building removed a few hundred feet from a busy street will be freer from traffic noise than one which directly faces a sidewalk adjacent to the street curb. The third principle of sound reduction is that of noise or sound absorption. Shrubs, trees, earthen embankments, and masonry walls that have been given special arrangement act as absorbers of sound, as do grass turf areas and dense vine growths. Care should be taken, however, to place plants in such a way as to make reduction in ventilation and in the entrance of natural daylight minimal. If the ground surrounding a school be generously provided with turf, vines, and other sound absorbing media, reduction of noise may be as great as from 8 to 18 decibels. The fourth method of sound treatment is that of shielding or interposing a noise attenuating barrier between a noise source and the persons affected. Shielding under outdoor conditions may be achieved by planting a hedge row or a row of trees which, depending on height, thickness and density, may be effective in excluding noise to the extent of 4 decibels, the amount which may be obtained by a cyprus hedge about two feet in thickness.

The application of these principles within the school building itself is often confined to the use of absorbing and shielding materials. A general rule of sound barrier construction is that the amount of noise reduced by a sound barrier is directly proportional to the density of the material making up the sound barrier. Thus a brick wall is more efficient in attenuating noise than one made of building board. Acoustic tile is widely used for sound absorption. Constructed of fibrous material, this tile may be obtained in either flat or perforated forms, which can be readily applied to wall and ceiling areas. Another method of creating a sound absorbing surface is to give the plaster of walls and ceilings a rough finish. Special acoustic plaster can also be used. A recent development relates to the use of fabrics containing lead for sound absorption.

One of the principal sources of noise in a school building is the ventilating or air-conditioning system — fans, air ducts, and inlet and outlet grills. In new building design, air distribution and return ducts should not pass through several rooms, but should feed into a central duct over a corridor or similar area. Quiet grills, motors, and fans,can be obtained. The streamlining of air transmission systems and the application of absorptive materials to the interior of the duct system will also aid in the reduction of noise. It is important to locate air handling machinery so that it will be as far as possible from occupied areas, and to use isolators to minimize transmission of vibration and noise into the building structure.

6. Effect of Openings: Although a school building wall may be designed so as to eliminate from 25 to 35 decibels of sound, any significant unshielded opening in the wall will reduce its effectiveness. For example, with open windows the effectiveness of the sound insulation of the walls of the building will be about 60 to 75% less than when the windows are closed. This is not to suggest elimination or constant closing of windows but rather to illustrate how openings affect sound control.

7. Sound Surveys: Usually the science of acoustics is one which requires the services of an individual trained in this field. However, lay people, the school superintendent or the head of the science department, can do much to determine the general noise background and make comparisons between noise levels which exist and those which are optimum or desirable. Today, effective, light-weight equipment for making sound level surveys is available from several commercial concerns. A most useful instrument is the sound level meter which may be purchased with a compact carrying case and which, when properly used, will give much valuable information.

To use the sound level meter, the operator turns it on, allows a suitable warm-up period, and then by selecting the proper scale reads directly in decibels the sound level at the point where the measurement is being taken. Measurements should be taken at various locations within a room or an outdoor space so that a true picture of the over-all condition is obtained. Contour maps of sound levels may be prepared, and will be found helpful in analyzing a noise problem. For more complex noise analysis, yet one which can be made by, say the science teacher of a high school, an instrument known as an octave band analyzer is available. The octave band analyzer requires its own sound level meter, and is not suitable for use with the compact hand models. A noise analysis with a band analyzer may reveal that the sound is loudest in the low frequency range where shielding is difficult, or that the intensity is greatest in the high frequency range where inexpensive shielding may be effective in reducing it.

8. Special Requirements: (1) Classrooms - In the design of classrooms, it should be remembered that long narrow rooms are less satisfactory than those which are more nearly square. Wall and ceiling construction may be designed to absorb 30 decibels or more of sound. Of great importance is the control of echo or reverberation, which may be caused if walls and ceilings be of a very smooth surface texture. Reverberation is the phenomenon of the reflection of sound. If the interval between the occurrence of the sound and noticing its echo or reverberation is long, interference with speech results. Satisfactory reverberation intervals for a small room are between .75 and 1.0 seconds. Reverberation may be controlled in a room by absorptive and reflective surfaces including objects, clothes, drapes or other soft materials. Control of reverberation is also achieved when acoustic tile is applied to the walls or ceiling. It is very important that partitions between classrooms be carefully and fully closed at the top to prevent the transmission of sound in ceiling spaces.

(2) Auditoriums: The acoustical designing of auditoriums is highly specialized science and a reliable acoustic consultant should be retained for this purpose. In general, the ratio of length to width of an auditorium should be about 1.2 to 1 and the walls and ceiling should be designed to give a beneficial reflection of sound. The volume of the room should be no larger than necessary, and most auditoriums will require public address systems. There is a great difference in the acoustic properties of an auditorium occupied by a speaker only and one occupied by a speaker and his audience. In the latter instance much of the sound is absorbed by the audience.

(3) Music Rooms: The sound requirements for music rooms are similar to those for an auditorium. Proper acoustic design should be provided by those who are experienced in this field. A general requirement is to avoid placing absorptive material near the music sources in order that the people who are playing may more easily distinguish each other's music. The use of smooth surface floors and paneling near the players' platform is desirable for reflection of sound. The music room is a source of noise, disturbing to other occupants of the building. Its walls should therefore be specially designed so that sound passing through the walls is attenuated to the levels required by other occupants of the building. If the music room, together

with the gymnasium lockers and/or swimming pool, can be placed in a separate wing of the school building, the major internal noise sources of the building will be set apart; and construction needed for sound shielding will be minimized. Another feature of music room construction is the so-called "splaying" of the walls and ceiling. This means that walls and ceiling and floor are not parallel to each other thereby setting up a condition in which sound waves are broken up and do not reflect back in the direction from which they came. As in other rooms, roughing the surface of the walls or providing soft materials within the rooms will help to absorb and deflect sound waves, and thus control the acoustic properties.

(4) Gymnasium: It is important that the gymnasium be as remote as possible from classrooms. It and its adjacent locker rooms should therefore be located ideally in a separate wing or, if possible, in a separate building. The ceiling of a gymnasium should be acoustically treated if financially feasible. Swimming pools fall in the same category as gymnasiums, and their acoustic properties should be designed in accordance with the general requirements for this type of space.

(5) Cafeteria: The cafeteria, with its buzzing, mealtime sounds, presents an acute acoustical problem. The problem may be alleviated by the use of acoustic tile on walls and ceilings in the eating and service areas, but the type of tile used should be cleanable. An effective material for noise control in cafeterias is suspended, perforated metal pan ceiling which may be cleaned by removal of the pans. In kitchen and dishwashing areas, particularly the latter, the clashing of dishes, glasses, and silverware causes much noise. The room housing the dishwashing machine should be adequately sound-insulated and also provided with ceiling surfaces of hard, sound-absorbing materials such as removable perforated metal pans. These should be made of noncorrosive material such as aluminum to prevent rusting.

(6) Health Rooms: It is important that any area or room set apart for health examination be made as quiet as possible in order to permit effective consultation between nurses, doctors, and pupils, as well as to afford a place of quiet for ill persons. For this reason, health rooms should have a sound level below 45 decibels, and the rooms themselves should be located in a quiet part of the building away from gymnasium and music rooms.

Audiometer rooms should be sound treated to produce noise levels not in excess of 40 decibels and as much below that as feasible. For this reason, the room itself should be faced with acoustic tile, and its walls particularly designed to prevent the transmission of sound into the room from the area around it. Audiometer rooms should be provided with acoustically designed doors which are available from several concerns.

(7) Existing Structures: It is evident that the best method for reducing noise is to build into a new structure or a renovated one the means whereby noise can be controlled. However, if the principles discussed above are utilized, noisy situations in old or existing buildings may be diagnosed and corrected to a degree which will be beneficial to the building occupants. The sound levels which exist in any room may be readily determined and many simple steps may be taken to reduce undesirable noise.

Check List

Item	Yes	No	Item	Yes	No
1. Has the sound level at a new school site been determined?			4. Does the school own or have access to a sound level meter?		
2. Have sound levels in all rooms of existing buildings been determined and noise controlled?			5. Have special areas been properly designed acoustically?		
3. Are the services of an acoustic consultant required for general or special noise problems?			6. Has every effort been made to eliminate unnecessary noise sources?		
			7. Are high noise areas placed as far as practicable from the classrooms and libraries in new school plants?		

Lighting

Poor lighting is a causative factor in producing defective vision, increasing accidents, and decreasing ability to work quickly and efficiently.

Sunlight is the best type of lighting, although artificial lighting is becoming more and more developed in approaching the efficiency of natural light.

The sun gives off wave-lengths which measure from 300 millimicrons to 3 microns. A micron (whose symbol is μ) is a millionth of a meter or a thousanth of a millimeter. A millimicron (whose symbol is $\mu\mu$) is a thousandth part of a micron.

Visible light waves range between 390 millimicrons and 760 millimicrons.

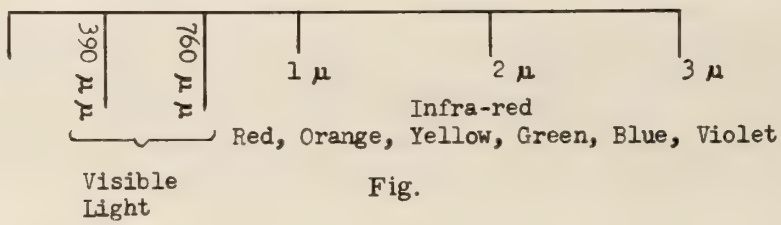


Fig.

Sunlight is composed of:

1 - 5% - - - untra-violet waves
41 - 45% - - - visible waves
52 - 60% - - - infra-red waves

The percent of ultra-violet waves in sunlight varies with altitude, latitude, humidity, temperature, season, time of day. Ultra-violet is greater in areas beyond the torrid zone. Infra-red waves are 10% greater in summer midday sun. Red waves are 45% greater in summer midday sun than in winter midday sun. Green waves are 90% greater in summer midday sun than in winter midday sun. Blue-violet waves are 25% greater in summer midday sun than in winter midday sun. Ultra-violet waves are 1000% greater in summer midday sun than in winter midday sun.

Water, sand, snow and clouds reflect ultra-violet waves. Sand reflects much infra-red waves. Snow reflects little infra-red but much ultra-violet waves.

Excessive ultra-violet light effects the eyes by causing conjunctivities, inflammation of the cornea, necrosis of the retina and eventual blindness. The formation of cataracts in the eyes is one of the causes of blindness. Snow blindness and blindness of welders are produced in this manner.

The Nature and Measurement of Light

Light, as the term is used, is radiation to which the eye is sensitive, i.e., radiation that can be seen. Various wave lengths of light (within the visible spectrum) are recognized by the normal eye as colors.

In dealing with light, an assumption is generally made, for convenience, that the rays are emitted by a "point source" (so small as to be without dimensions) and radiate in all directions, forming a sphere that expands constantly around the light source as its center. The surface of this hypothetical sphere is referred to the radiant sphere.

With these ideas in mind, some of the pertinent characteristics of light can be considered and the various arbitrary units by which light-measuring instruments are calibrated can be defined. These light-measuring instruments are called light meters. There are two ways of measuring illumination in a practical manner:

1. Photoelectric cell which measures the intensity of light by transforming the light energy to electrical energy.

2. Foot candle meter which measures the intensity of the light by comparing a standard intensity on a screen with the reflected light from the light source on a proximal screen.

The photoelectric devices convert the energy of visible radiation into electricity. The electricity that is generated in this way is measured by a microammeter which is an integral part of the meter and which is usually calibrated in units that are called foot-candles.

Brightness Dims Fast as Light Recedes From its Source. This is an application of the Inverse-Square Law which states: "The manner in which any physical quantity (in this case, the intensity of light) varies with the distance from its source, is inversely as the square of the distance." This is another way of saying that the intensity of light changes in proportion to the product of the ratio of the first distance to the second distance (at which the intensities are measured) multiplied by itself. Assuming a distance of 3 feet (first distance) and an intensity of 36 foot-candles, the intensity, then, at 6 feet (second distance) would be:

$$36 \text{ foot-candles} \times \frac{(3 \text{ feet})}{6 \text{ feet}} \times \frac{(3 \text{ feet})}{(6 \text{ feet})} = 36 \times \frac{9}{36} = 36 \times \frac{1}{4} = 9 \text{ foot-candles.}$$

And, conversely, an intensity of 4 foot-candles at 9 feet (first distance) would increase to 36 foot-candles at 3 feet (second distance):

$$4 \text{ foot-candles} \times \frac{(9 \text{ feet})}{(3 \text{ feet})} \times \frac{(9 \text{ feet})}{(3 \text{ feet})} = 4 \times \frac{81}{9} = 4 \times 9 = 36 \text{ foot-candles}$$

This will be further clarified in the defining of lumen.

One candle-power is that amount of light (radiated in all directions) that is emitted by the flame of an international candle. (An international candle is simply a candle that meets certain standard specifications.) Candle-power is the unit of intensity of a light source. A watt is a unit of electrical current consumed by a lamp. One watt produces approximately one candle-power.

The lumen is the unit of luminous flux. It is equal to the flux through a unit solid angle (steradian) from a uniform point source of one candle, or to the flux on a unit surface all points of which are at unit distance from a uniform point source of one candle. One lumen per square foot is equivalent to one-foot candle. A lumen is just a little less than one-twelfth of a candle-power. It is defined as the part of the light from the flame of an international candle that makes up a certain area of the radiant sphere's surface. That certain area is equal to the square of the sphere's radius. There are approximately 12.5664 such areas on the entire surface of the sphere. (Area of a sphere is $4\pi r^2$; divide this area by r^2, and the quotient will be 4π, which is equal to about 12.5664.)

As the luminous sphere expands, its radius grows, and so also does the area that determines a lumen of light. But, as the lumen-determining area gets larger, it gets farther away from the center of the sphere, i.e., the radius gets longer. The light, traveling farther from its "point source," covers more area and therefore grows fainter. The total amount of light does not change; nor does the lumen.

The foot-candle is a measure of brightness-intensity of light. It is the brightness of the light that, having been emitted by the flame of an international candle, impinges upon a surface that is 1 foot away from the center of the source of light. The intensity of illumination on a surface varies inversely with the square of the distance from the source of light. One lumen of light per square foot of surface has a brightness of 1 foot-candle. Foot-candles multiplied by 1.25 is brightness in foot-lamberts.

The lambert, like the foot-candle, is a measure of brightness. It is the brightness that a surface of 1 square centimeter has when it is either emitting or reflecting 1 lumen of light.

The foot-lambert, like the foot-candle, and the lambert, is a measure of brightness. It is the brightness that a surface of 1 square foot has when it is either emitting of reflecting 1 lumen of light. Brightness, in foot lamberts, is the reading in foot-candles multiplied by 1.25.

The reflection factor of a surface is expressed as a percentage. It is the percent of impinging light that is reflected. If 10 lumens of light strike a surface, and 5 lumens are reflected, the reflection factor is 50 percent.

Brightness ratio is the difference in brightnesses within the visual field which has influence on the adaptation of the eyes. It is defined in more detail in relation to these terms:

1. Visual Field: This field (the vertical and horizontal distance that the steady gaze forward can span at any given distance) is different for each individual. Its angle at the eye is approximately 120^{o} vertically, and 160^{o} horizontally.

2. Visual Task Field: A field of about 1^{o} (1/4 inch at a distance of 14 inches from the eye) upon which the eye focuses in critical seeing.

3. The Surrounding Field: This field is arbitrarily limited to an angle of 60^{o} at an eye. (At a displacement of 30^{o} from the optical axis, a line between the pupil of the eye and the center of the visual task field, visual activity is only 1 percent of the value that it has in the 1^{o} visual task field.) The 60^{o} angle of the surrounding field spans a distance that is always equal to the distance from the eye.

4. The Peripheral Field: The outer regions of the visual field, beyond the surrounding field, make up this field.

The brightness ratio compares the brightness of a visual task field with the brightness of the predominant area of brightness either in the surrounding field, or in the peripheral field. This ratio is made up of arbitrarily assigned values which have a specific relationship to each other.

The brightness of the predominant area of brightness in either the surrounding field or the peripheral field is assigned a value of 1. This predominant area of brightness is that area from which more than 50 percent of the total light from the surrounding field or the peripheral field is either reflected or emitted.

The brightness of the visual task field is expressed relatively to the brightness of the predominant area of brightness. It may be equally bright, brighter, or less bright.

The ratio of brightness gives, first, the brightness of the predominating area of brightness (always expressed as unity, or 1) and, second, it gives the relative brightness of the visual task field. If the light from the visual task field be five times as bright as that from the predominant area of brightness, the ratio is 1:5. If the light from the visual task be one-half as bright as that from the predominant area of brightness, the ratio is $1:\frac{1}{2}$.

For the visual task field and surrounding field, a brightness ratio of 1 : 1 is eminently desirable for prolonged critical seeing. Ratios between 1 : 1 and 1 : 5 are most desirable. Those between 1 : 5 and 1 : 10 are acceptable (but less so as the right-hand number approaches 10). Brightness ratios between 1 : 10 and 1 : 100 should not be tolerated.

The brightness ratios, however, between the visual task field and the peripheral field can be allowed to range up to 1 : 100; but the smaller the right-hand number, the more desirable the ratio.

If the surrounding field be not entirely illuminated (that is, if the illuminated area of this field be lesser in extent than the entire field) optimum brightness ratio range is reduced; it should not go beyond the range of 1 : 1 and 1 : 5, and the ratio of the visual task field to peripheral field brightness range should also have lower contrast.

Brightness ratios in which the right-hand term (visual task brightness relative to surrounding field brightness) is fractional, should always be avoided. Glare conditions should also be avoided either in the surrounding field or the peripheral field. They are completely inadmissible in the visual task field.

Glare refers to light that enters the eye from any intense light source that is markedly brighter than its surroundings. However, glare might better be defined as light of high intensity, reflected or emitted, generally, but not always, set against a background of illumination that is of a lower intensity and which creates extreme contrast. The intense light makes the iris of the eye contract. This reduces the total amount of light that reaches the retina. The reduction in amount of light that reaches the retina applies to light of lower intensity (the background illumination) as well. Thus, visibility that is based on less intense light is considerably reduced under glare conditions.

Glare therefore depends upon:

1. The intrinsic brilliancy of the light source.

2. The distance of the light from the eye.

3. The angle of the light producing glare on the eye.

Glare is unwanted brightness and is distracting and annoying, often to the extent of causing extreme discomfort, and even pain. It is often referred to as "misplace brightness".

Vision

Visibility is the clearness with which one can see an object. Visibility is increased both by brightness difference within the visual task and by intensity of illumination on the task. The reduction in brightness ratios (contrast) makes visibility more difficult, and coupled with reduction in brightness, the difficulty is multiplied. Visibility increases rapidly up to 5 foot-candles, gradually from 5 to 10 foot-candles, very slowly from 10 to 20 foot-candles and with decreasing perceptibility up to about 40 foot-candles. The less the brightness contrast, the greater the illumination necessary to clearly see an object. The contrast between the field at which one looks and the surrounding field should be small. As age increases, greater illumination becomes

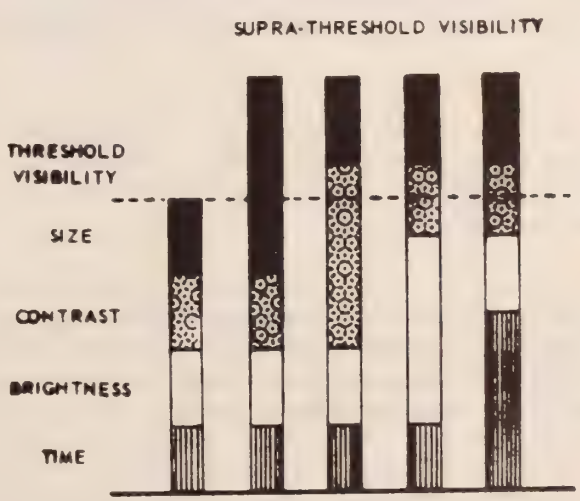


Figure 1. The interdependence of the four fundamental factors which determine the visibility of objects.

necessary. Speed of vision increases with increased illumination.

An object, a visual task, or a scene is made visible by several factors. These factors exist in various combinations. Four of the factors are fundamental, i.e., size, contrast, brightness, duration (see Fig. 1). To maintain visibility the artihmetic product (loosely speaking) of these factors must not change. If one be reduced, one or more of the others must increase.

Contrast, as has been explained, is related to brightness; it can also be related to color, but color-contrast is usually a secondary factor and is treated separately.

Vision and Age: The number of vision impairments that are found per thousand persons is much greater among those whose age is 64 years or more than it is in younger age groups. In this bracket, approximately 75 out of every 1,000 have some visual impairment; this ratio increases to 160 per 1,000 at ages of 75 years and over.

The importance of illumination in this connection can not be emphasized too much when one considers the difference in the increase in power of accommodation (one factor of the ability to see) for persons with subnormal and normal vision, at various levels of intensity of illumination.

One-half of the residents of nursing homes are 80 years old or more. These residents are likely to have visual impairments of one sort or another, hence good illumination is much more important to this group than it is to younger people.

Among the aged, the field of vision is narrower, the speed of adaptation to varying intensities of light is lower, and the minimum of light that can be perceived is less than it is among younger people. Also, the lenses of older people's eyes appear to have lower resolving power as well as less power of accommodation. They are unable to "see" details as clearly in dim illumination and they lose their capability to do so at a rate that is proportional to their increase in age.

Many old persons try to perform visual tasks under great handicaps; some give up reading without knowing that in many cases more light would be helpful. It is obvious that sight among the aged can be aided materially by higher levels of illumination.

Taking as a base, the 20-year-old normal eye, optimum conditions of visual acuity, contrast, and speed of vision at various ages are governed by brightness.

Visual acuity is the ability to distinguish detail, and is often expressed as a ratio. This ratio has as its numerator the distance over which the individual being tested can distinguish a given line of letters on a test chart (Snellen or AMA), and for the denominator the distance over which a person with normal vision can distinguish the same line of letters. In general, visual acuity declines with age. Figure 2 shows the average relationship of visual acuity to age.

In case of defective vision, or fine detailed work, or lack of contrast, the foot candles of illumination should be much higher than for normal conditions.

If one works where it necessitates going from daylight to artificial light very often, the artificial light should have greater foot-candles of illumination than normally.

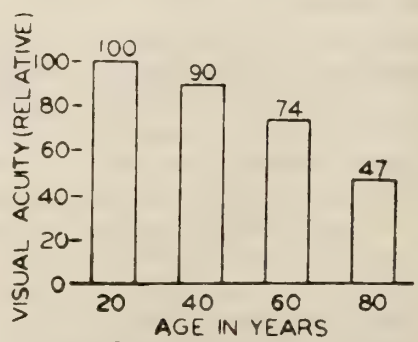


Figure 2. Variation of visual acuity with age (6).

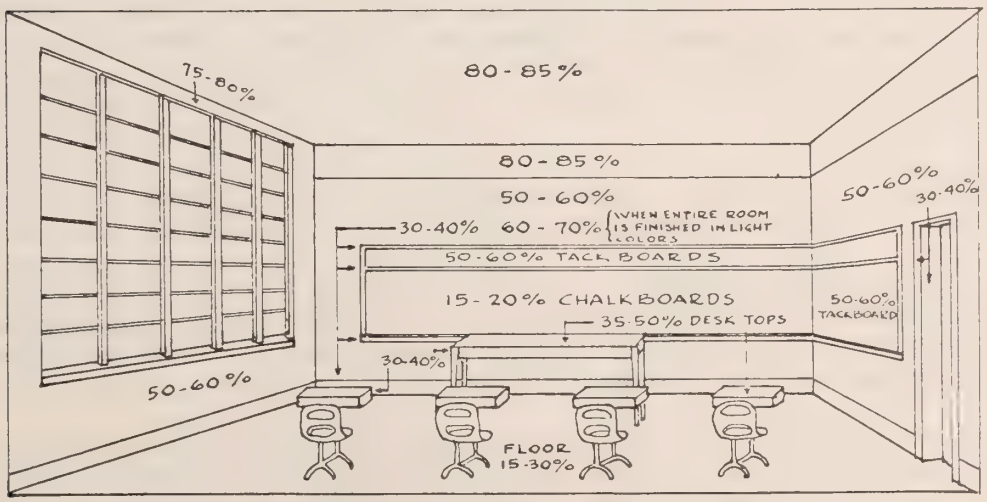
Light must be on the work and not in the eyes. The nearer the light source to the line of vision, the greater the glare. There should not be a bright spot in the field of vision. At an angle of 10 degrees, a 100 watt lamp produces as much glare as a 225 watt lamp of 15 degrees above the line of vision. A light 30 degrees above the line of vision is practically glareless.

Table 2. Recommendations for Limits of Brightness Ratios in Schoolrooms

Difference in Brightness in Visual Field	Ratio
a. Between the "central visual field" (the seeing task) and immediately adjacent surfaces, such as between task and desk top, with the task the brighter surface	1 to 1/3
b. Between the "central visual field" (task) and the more remote darker surfaces in the "surrounding visual field", such as between task and floor	1 to 1/10
c. Between the "central visual field" (task) and the more remote brighter surfaces in the "surrounding visual field," such as between task and ceiling	1 to 10
d. Between luminaires or windows and surfaces adjacent to them in the visual fields	20 to 1

Table 3. Brightness Limitations

Zone (0^0 is directly beneath luminiare)	Recommended Brightness Limits in Foot-lamberts
60^0 - 90^0	225
45^0 - 60^0	450
0^0 - 45^0	1000



Recommended Classroom Reflectable Values

Reflected light - Light which strikes any surface is either absorbed or reflected. The light which strikes the surface is known as the incident light and the light which is returned from the surface is known as the reflected light. It is the latter which gives brightness to a surface and which itself has no light source. The ratio between reflected light and incident light is known as the reflection factor or coefficient of reflection. This percentage of incident light that is reflected by a surface is also known as the reflector factor or reflectance. Thus, if a surface reflects 80% of the incident light, 80/100 or .80 is the reflection factor or coefficient of reflection. Therefore the brightness of an illuminated surface divided by the reflection factor will be equal to the intensity of illumination. In the above example, if the brightness of the illuminated surface be 80 foot-candles, then 80/.80 or 100 foot-candles would be the intensity of illumination.

Light is reflected in several ways. If it strikes a mirror the reflected rays remain parallel. This is known as specular reflection. Light which strikes dull, white paper or a white powder has its rays scattered to all possible angles. This is known as diffused reflection. Reflected light made up of a combination of both specular and diffused reflection is known as composite reflection.

Reflection resulting from wall and ceiling surfaces is very important in illumination of rooms. Of light which strikes walls or ceilings, part is absorbed and the balance is reflected to strike other surfaces where more will be absorbed. This contributes to increased distribution of illumination over that of the lamp alone. Therefore ceilings, walls, and floors of low absorbing and high reflecting powers aid materially in illumination. The lighter colors reflect more light than the darker ones, black being completely absorbent unless the surface be highly glazed or polished in which case there will be some specular reflection.

Table 3. Reflection Factors of Paints of Various Tints

Classification	Reflection coefficient percent
Gloss Mill white	74 to 82
Flat mill white	78
Light cream	74
Light pink	67
Light yellow	65
Light blue	61
Light buff	58
Light green	47
Light gray	49
Medium blue	36
Medium gray	30
Red	13

Diffuse light producing no shadows is desired ordinarily. In printing work, shadows are required because the relief print can only be distinguished by shadows. With as little as .1 foot-candle, a printed page can just be discerned. For protracted reading not less than 10 foot-candles should be used and as high as 40 foot-candles are desirable. For auditoriums 5 foot-candles are adequate.

There is a tendency, at present, to recommend greater illumination than in the past. The following Table 4 on school-lighting requirements are in accordance with newer recommendations.

Types of Artificial Lighting Systems

In spite of the great strides which artificial lighting has made in late years and the difficulties sometimes encountered in obtaining effective natural light, the latter will remain desirable for homes, schools, offices and even in industrial lighting where possible.

We are not, however, interested merely in foot-candles. We are interested in the ease and effectiveness of seeing, which is largely a matter of brightness balance within the total visual environment. The ideal installation would be one in which the lighting units would not be noticeable, because their brightness would blend with the surrounding surface.

Cove lighting provides good conditions, but is quite expensive. The suspended opaque bowl is not satisfactory, because the opaque bowl is darker than the ceiling. The open bowl and cove types require frequent cleaning, because their effectiveness depends upon reflection from the fixture surface as well as the ceiling. Direct lighting is sometimes advisable for special local areas, but totally direct units are not satisfactory for general lighting, because they do not emit upward light to give the ceiling the desired brightness.

Lamps may be totally enclosed in diffusing glass or plastic bowls or troffers, or shielded from the normal fields of vision by recessing or by protecting baffles such as the egg-crate shade.

If lights be recessed in the ceiling, they should be designed to throw sufficient light to the ceiling to prevent excessive brightness difference between the fixture and the ceiling.

The most common method of filament installation has been the suspended glass-enclosed lamp, but the concentric-ring fixture with a silvered-bowl lamp is growing in popularity.

"Daylight" artificial light gives no better illumination than regular yellow light. It does aid in distinguishing colors and is much cheaper to operate. Fluorescent light is produced by passing an electric discharge in a tube of gas. Sodium gas produces yellow light, mercury gas produces blue light, and neon gas produces red light. Ultra violet light waves acting on a fluorescent substance causes the ultra-violet waves (invisible) to change to visible light.

Fluorescent lamps are usually installed in four-foot units of two or four 40-watt tubes each. But for high levels of illumination and better distribution, continuous strip lighting is becoming popular. Strip lighting may be designed to run with either axis of the room, in one to four-tube units, and on 3 to 12-foot centers. The "ceiling of lights" is probably a good answer for such situations as school rooms. A larger number of closely spaced, low-powered lighting units may provide better distribution than fewer high-powered units spaced far apart. The proper height of a lighting unit will depend upon its design, spacing, and the height of the ceiling.

Table 4. School-lighting Requirements

Places	Recommended foot-candles
On the space:	
Walks, drives, and other outdoor areas, if used at night	0.5
Playgrounds, outdoor, if used at night	2.0
Playgrounds, outdoor, if used at night for basketball, baseball, etc.	10.0
Storage spaces, passages, not used by pupils	2.0
Boiler rooms, power plants, and similar auxiliary spaces	5
Stairways, landings, corridors, aisles, exits, elevator cars, washrooms, toilets, locker spaces, dressing rooms	10
Recreation rooms, gymnasiums, swimming pools, reception rooms	20
On the work:	
Auditoriums, assembly rooms	10
Auditoriums, assembly rooms if used for class or study purposes	30
Classrooms, studyrooms (at desk tops)	30
Classrooms, studyrooms (at charts, blackboards)	30
Libraries (reading tables, catalogues)	30
Libraries (bookshelves, vertical plane)	30
Laboratories, general	30
Local illumination	50
Manual-training rooms, workshops, etc., general	30
Local illumination	100
Drafting rooms, sewing, typing, general	30
Local illumination	100
Sight-Saving Classroom	50

Many objections to the earlier fluorescent installations have been overcome in recent designs. The choice of this type of lighting should be made on the basis of all conditions in each situation as analyzed by a competent authority. In general, it is probably advisable to use fluorescent lighting in classrooms or similar situations where it is desired to maintain intensities of artificial light of 40 foot-candles or more.

Some of the advantages of fluorescent lighting are:

1) It produces approximately 2 1/2 times as much light per watt of consumed current.

2) It produces less surface brightness which permits a greater percentage of direct light without violating brightness balance.

3) It produces much less heat per light output.

Table 5. Lighting Requirements for Various Situations

Situations	Recommended foot-candles
Trains	6
Churches, Hotel lobbies	8
Banks	10
Reading Rooms	12
Barber Shops	15
Art Galleries	20
Casual Seeing	5
Factories	10
Clerical Work	20
Watch Repairing	50
Sewing Dark Goods	100

The chief disadvantage of fluorescent lighting is the higher cost for fixtures.

Fluorescent lamps in their present state of development should be shielded from the field of vision. A bare 40-watt fluorescent tube has a brightness of 1, 900 foot-lamberts when viewed at a right-angle to its axis, and 1, 400 foot-lamberts from a 30° angle. With proper shielding the brightness of these lamps may be reduced to 500 foot-lamberts. The shielding should be such that the side-view of the tubes will not be visible at any angle of less than 45° to the horizontal from sitting position, and the end view, not from an angle of less than 35° to the horizontal. No bare lamp should be exposed to vision in a classroom under any conditions.

There are a few precautions which may improve lighting and save future trouble and expense:

1) Do not use less than No. 12 wire.
2) Do not put more than 1, 000 watts on a single circuit.
3) Do not light more than 400 square feet on one circuit.
4) Install ample wiring and panel service for future need.
5) In school rooms with conventional windows on one side only, wire the lights on the inside of the rooms on separate circuits so they can be used to supplement natural light.

Table 6. Distribution of Light by Types of Illumination

Classification	Approximate Distribution of Light Emitted by Luminaire	
	Upward	Downward
Indirect	90 - 100%	10 - 0%
Semi-Indirect	60 - 90	40 -10
General Diffuse	40 - 60	60 -40
Semi-Direct	10 - 40	90 -60
Direct	0 - 10	100 -90

Indirect Lighting (Fig. 3)

With the indirect system, light is reflected diffusely to all parts of the working area from the ceiling and upper sidewalls. In effect, the entire ceiling becomes the apparent light source. Indirect lighting should be used where it is desired to reduce shadows and reflected glare as much as possible. For levels of illumination of the order of 50 foot candles, particular care should be taken to provide proper brightness ratios by maintaining recommended reflection factors of walls and furnishings.

Because the ceiling constitutes an important part of an indirect lighting system, careful attention must be paid to having it as light in color as possible and to maintaining it in good condition. It should be given a non-glossy white or off-white finish with a high reflection factor. The lighting units should be such that they can be easily cleaned, because a layer of dust and dirt can absorb a considerable amount of light. The exterior of opaque bowls should be light in color to

reduce brightness contrasts with the ceiling. With filament lamp installations, inside-frosted bulbs should be used to obviate streaks and shadows on the ceiling which result from clear lamps in some luminaires. (Inside-frosted lamps have the same light output as clear lamps.) Silvered bowl lamps are often used in indirect luminaires. The spacing and suspension of luminaires should be such as to provide a fairly uniform ceiling brightness.

The choice between filament and fluorescent lighting with indirect systems is usually one of economics, rather than of quality, and involves costs of equipment, installation, energy for operation, and maintenance. The relative importance of these elements will vary in different communities because of differences in basic costs.

Semi-Indirect Lighting (Fig. 3 b)
A semi-indirect lighting system should be used where greater utilization is desired due to the larger downward component as compared with the indirect system but where good diffusion still is required. Since this system also utilizes the ceiling as the main source of light, the same consideration as for indirect lighting should be observed in regard to ceiling finish and maintenance. As the percent of direct lighting from the luminaires increases, the danger of objectionable direct and reflected glare increases, particularly with filament lamp luminaires. At the same time, the danger of objectionable ceiling brightnesses at levels of illumination around 50 foot-candles diminshes.

General Diffuse Lighting (Fig. 3 c, d)
A general diffuse lighting system should be used where it is desired to diffuse light generally throughout the room with more illumination for the same total watts than from indirect or semi-indirect systems. Shadows are more noticeable and some difficulty may be experiences with both direct and reflected glare.

One type of luminaire of this classification for filament lamps is the diffusing glass enclosing globe. The glass should have good transmission but should be sufficiently dense to avoid a bright spot due to the lamp.

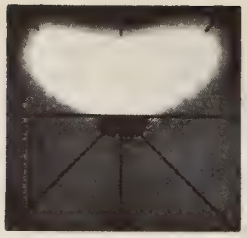
Unshielded diffusing globes and bare fluorescent lamps in the normal field of vision do not represent good practice for lighting in classrooms since they are generally too bright from the standpoint of direct glare. However, suitable shades may be used on enclosing globes which will make it possible for them to comply with the brightness limitations. In this case special attention should be given to mounting height and shielding angle.

An acceptable type of schoolroom luminaire in this classification is represented by the direct-indirect fluorescent units in which the brightness in the normal field of view is low due to the use of baffles, louvers or diffusing media.

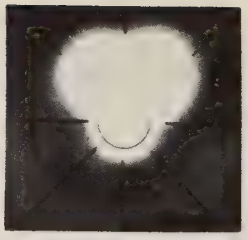
Direct-Lighting (Fig. 3 f)
This system should be used where it is desired to have maximum utilization of light at the working plane and, in general, better maintenance. With direct lighting an undesirable brightness ratio may result unless some means of illuminating the ceiling be provided such as special provision for a small percent of upward light from the luminaires or the use of light-colored floorings, desk tops and furniture finishes.

In discussing direct lighting luminaires and installations, it is particularly desirable to differentiate between those designed for fluorescent and those for filament sources. This is due to the lower lamp brightness and the diffusion of the fluorescent lamps. The comments below are also applicable to a lesser degree to the semi-direct, general diffuse, and semi-indirect systems.

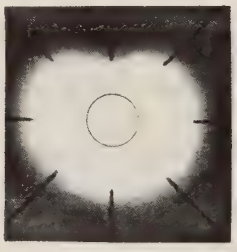
Direct Lighting with Filament Lamps —While, in general, direct systems provide illumination on the working surfaces most efficiently, this is usually at the sacrifice of other factors. For example, disturbing shadows result unless the area of the lighting units be unusually large. Direct and reflected glare will be distressing unless the relative brightnesses be kept within comfortable limits. Direct lighting with filament lamps is therefore not recommended for classrooms.

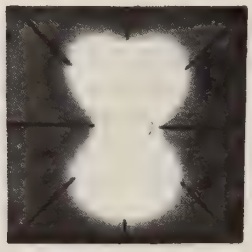


a. Indirect Lighting

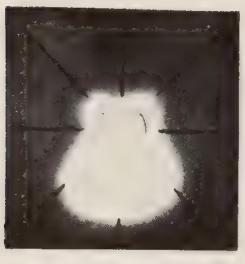


b. Semi-indirect Lighting.

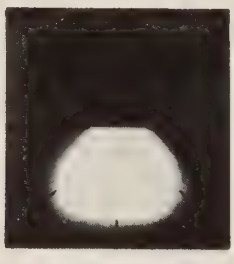




General Diffuse Lighting
c. Diffusing enclosure d. Direct-indirect



e. Semi-direct Lighting



f. Direct Lighting

Fig. 3 Light Distribution by Various Types of Illumination

Direct Lighting with Fluorescent Lamps —Certain types of direct fluorescent luminaires may be so installed that the resultant illumination approaches totally indirect lighting in quality from the standpoint of uniformity of illumination over the working area, the absence of objectionable shadows, and lack of direct glare. Such results are attainable with continuous recessed troffers or ceiling mounted or suspended direct lighting reflector equipment on close centers which provide shielding of the lamps from direct view within normal viewing angles and which present surface brightnesses in these angles which are within comfortable limits. Such equipment must very carefully designed and the brightness exposed downward must be limited for it to qualify.

If desk tops and other furniture have a dull finish, be light in color and the general brightnesses be high because of foot candle levels of 30 or more, the reflected glare usually found in direct lighting installations will be greatly reduced and satisfactory brightness ratios may be obtained. The direct scheme described also permits higher levels of illumination without uncomfortable ceiling brightnesses.

School Lighting

Poor illumination in school rooms may be a very important factor in causing defective vision and consequent low-grade scholarships among the children, therefore this item must be scrupulously examined. The amount of transparent glass surface admitting daylight should not be less than 20% of the floor area. Light should enter the school room from the left side in order that shadows of the hand, pen, and pencil should not fall upon the paper while writing. Thus the desks in the room should always be arranged so that the children's left hands will be nearer the windows. Right sided entrance of light is never satisfactory, and light entering from behind the teacher who usually faces the pupils is not permissable. In order for the sunshine not to cause

glare, the school room should be illuminated from windows occupying only one side of the room. Pupils, when sitting at their desks, should face a blank wall. The glass area of the windows should extend about 4 feet from floor to within 6 in. of the ceiling in order that the far corners of the room may receive as much natural daylight illumination as possible; and in order to prevent glare, they should not extend forward beyond the front rows of desks. Rear windows are undesirable since they make the teacher face the light. Each window should have translucent shades, operated from the middle of the window up and down permitting independent control of sunshine through the upper or lower half of the window. The maintenance of clean walls is of utmost importance since dirt absorbs the light. The width of a classroom is usually recommended to be not more than 24 feet, for otherwise impracticable high ceilings would be necessary in order to allow the light that reaches the right side of the room to be sufficient. A ceiling 13 feet high would under ordinary circumstances give sufficient light in a room 24 feet wide. Light entering the upper one-third of the window is as effective as the light from the lower two-thirds.

Windows should be clean; no draperies or shrubbery should exclude light. No trees nor tall buildings large enough to obstruct light should be within 50 ft. of the windows.

An ordinary cheap shade can be converted into an adjustable shade by attaching the shade to a strip. This strip is suspended by a cord which passes through an automatic lock pulley, attached to the top of the window frame. Shades having double rollers placed near center of windows and working upward and downward are satisfactory. Shades should be properly adjusted as often as is necessary, and when not in use should be completely rolled up. Only windows receiving direct sunlight require shades. Monitors may be appointed to regulate shades and to keep the windows clean.

The limitations of the 22' x 30' x 12' classroom set in the past due to the problem of fenestration is rapidly being modified by the modern activity program being developed in the school curriculum. School architects and engineers have been pressed to reexamine the whole problem of fenestration for school rooms with capacities of 30 to 35 pupils requiring 25 to 30 square feet per pupil in the elementary grades, 30 to 75 square feet per pupil in the laboratories and workshops of the secondary schools, and 20 to 30 square feet per pupil in the academic area.

Fenestration is defined as the technique of controlling light from natural sources by regulating the type, size, location and orientation of the sources of natural light, and the application of shades and other devices.

Most of the newer types of fenestration are based on: Warm climate, little or no snow, abundance of sunshine, large level site, one story structure, and single-loaded corridors. Under these conditions, some excellent results have been achieved at no additional cost.

The need for larger rooms has necessitated widening them, since increasing the area by merely lengthening them would upset the efficient utility of the rooms. With the tendency for wider rooms than the old standard, windows of four feet from floor and 6 inches from ceiling would throw insufficient light to the opposite side of the room. This can be overcome by adequate artificial lighting, but an effort to supply adequate natural light should be made. This can be done by:

a) Providing saw-tooth skylighting oriented to the solar north in order not to require window shades.

b) Permanently shielded supplementary light sources such as directional glass block and horizontal louvers at least 6 feet from the floor. Light sources from high panels opposite the walls where the regular windows are located give good lighting if permanently shielded so as to reflect the sun rays and sky reflection to the ceiling.

c) Sloping ceilings which are lower on the regular window side so that the ceiling reflects light to the side opposite the regular windows.

d) A clerestory window facing the same direction as regular windows. For example, if the outside third of the ceiling next to the regular window is 9 or 10 feet high, the inner two-thirds of the ceiling is stepped up to 12 or 14 feet, thus providing high vertical clerestory windows parallel with the regular windows and supplying ample natural light to the would-be dark side of the room.

Multi-story school houses provide even more complicated structural problems.

Room and Furniture Surfaces

Ceilings should be finished with a reflection factor of 85%, which is practically white and near maximum for acoustical tile.

Walls from ceiling to wainscoting should be finished to provide a reflection factor of 60% or more. The wainscoting including the baseboard should have a reflection factor of around 40%. It is permissible to drop the ceiling finish to the picture moulding, and to continue the 60% wall finish to the floor. Dark colored walls not only reduce lighting efficiency, but tend to introduce glaring contrasts. The effect of low bottom windows has a tendency to produce glare on the opposite walls, and may be neutralized by painting the lower 3 or 4 feet of the wall brown or dark green.

Trim may be finished in a different hue, but with a saturation which will give it approximately the same brightness as the adjacent walls.

Floors should be finished and maintained with a reflection factor of from 30 to 40%. Light-finished hardwoods and light shades of tan composition come within this range. Floors of distinct contrasting color patterns should be discouraged.

Chalk Boards should be confined to the front wall. The best combination is the use of a just-off-white chalk on a light-green chalk-board which has a light-reflection factor of approximately 20%.

Equipment Surfaces should be of non-glossy finish with reflection factors of from 30 to 40%.

Color Schemes. Green and blue are cool and tranquil colors and may be used in sunny areas. Orange and yellow are warm and cheerful colors and may be used in areas which receive little or no direct sun. Most hues may be selected for color schemes if they harmonize and be esthetically satisfying. The important consideration is that the saturation be sufficiently diluted with white to give the specified brightness. Colors should be selected on the basis of reflection factor, artistic appearance, ease of maintenance, and adjustment to the orientation and use of the area. Flat white, cream, tan, or light green are good colors. White is more tiring to the eyes than the other 3 colors, but is it preferable for ceilings since the eyes are usually not fixed in that direction.

Artificial Lighting in Schools

The optimum light in a school room is between 15 and 40 foot-candles, depending on the type or activity. High illumination has a tendency to stimulate the pupils and make them more attentive; subdued illumination is conducive to restfulness and inactivity. Because daylight is not a constant quantity, the ideal school room should have supplementary artificial lighting. No light in a school room should be too brilliant; the maximum brightness should not exceed 300 foot-candles; no tungsten lamp should exceed 100 watts. Semi-indirect lighting is the most satisfactory artificial illumination for a school room, except for the newer and more expensive fluorescent lighting. In a light colored room, from 1 to 3 watts per square foot of floor space will supply from 10 to 30 foot-candles of illumination. With proper diffusion, artificial light in any practical amount is harmless. Lights are best located on the ceiling. Wall lights usually throw shadows, and if not at least 30 degrees above the line of vision, they will produce a glare. As glare increases, it produces successively distraction, discomfort, fatigue, and reduced visibility. On blackboards, some of the writing is often invisible from a part of the school room because of the glare of reflected light. If good greenish-black slate be used, cleaned regularly with coal oil and resurfaced when old, this handicap is readily controlled. Tilting the blackboards forward and adjusting the translucent shades or venetian blinds will also aid in controlling glare.

In school rooms where home economics, woodwork, or machine work is taught, the light must be greater than in the other rooms.

Lamps, glassware, and window-panes must be kept clean. Dust and dirt can cause a decrease in lighting efficiency of 10 to 40%. Water is cheaper than watts.

A simple method of calculating roughly the approximate brightness of artificial light is as follows: On a white horizontal surface one foot below a tungsten lamp the brightness produced is

about one foot-candle per watt, and decreases by the law of the inverse square. Therefore if the white surface be three feet away from the lamp, the brightness will be 1/9 as bright, if 4 feet away, the brightness is reduced to 1/16.

Another "rule of thumb" method for calculating roughly the relationship between wattage and foot-candles when the school room surfaces and furniture are properly finished is: 6 foot-candles on the desks for each watt per square foot from a good incandescent installation, or 15 foot-candles for each watt per square foot from well-designed fluorescent light. Thus, in a properly finished 24' x 36' school room, about 20 foot-candles of artificial illumination may be expected from six 500 watt, silvered-bowl, concentric-ring incandescent units or 30 properly shielded 40 watt fluorescent tubes arranged in units or strips.

Calculation:	24 x 36	=	864 sq. ft.
	6 x 500	=	3000 watts
	3000 ÷ 864	=	3.5 watts per sq. ft.
	6 x 3.5	=	21 foot-candles of illumination with incandescent lamp.
	30 x 40	=	1200 watts
	1200 ÷ 864	=	1.4 watts per sq. ft.
	15 x 1.4	=	21 foot-candles of illumination with fluorescent lamp.

If the fenestration be designed for a minimum of 10 foot-candles from natural sources, either of the foregoing installations should result in a total minimum of about 30 foot-candles from combined natural and artificial sources.

Safety

In considering the problem of safety, practically every entity of site and structure, every piece of equipment, and every technique, procedure and practice which makes up the physical and social environment of the child in a school is involved. It is not only important that the school environment be safe for the child, but that the child learns from practice and studies in school to carry the safety campaign into his home and community.

Place of Accidents in School Building	Types of Activities Causing Accidents
33% in gymnasium	42% in unorganized activities
19% in halls and stairs	18% in football
18% in shops	11% in baseball
13% in class rooms	21% in other organized games
17% in other places	8% in apparatus

Percent of Accidents on School Grounds by Grades

Kindergarten grade	= 1%	Seventh Grade	= 9%
First grade	= 6%	Eighth grade	= 8%
Second grade	= 7%	Ninth grade	= 8%
Third grade	= 7%	Tenth grade	= 6%
Fourth grade	= 9%	Eleventh grade	= 7%
Fifth grade	= 10%	Twelvth grade	= 7%
Sixth grade	= 12%	Unclassified	= 3%

In the past there have been about 5 school fires for each day in the year. Many schools at present are fire-traps.

Table 7. Causes of Death in 60 School Fires (Public Schools, Private Schools and Colleges) Between 1903 and 1938

Causes	No. of Deaths
Inadequate exits	309
Exits cut off by fire	43
Exit doors open in, windows barred	36
Suffocated while asleep	28
Fire fighting and salvage	25
Burns and ignition of clothing	9
Special hazards*	307
Miscellaneous and no data	70
Total	827

*Includes 297 killed in New London, Texas from gas explosion. From American Ass'n. of School Administration, Safety Education, 1940.

The Building Code recommended by the National Board of Fire Underwriters will give valuable information relative to fire-resistive construction. If the building be of more than one story, the material used in it should be fire-resistive. Frame and wood-constructed buildings should never exceed one story in height. It is of prime importance that an architect acquainted with fire safety be chosen to design a school. It would help a great deal if every political unit in our country had a building code.

Study has indicated that school fires usually start in one of the following areas:

1) The heating system or cold storage plant.
2) The manual training room or shops.
3) The janitor's room where cleaning supplies and paint are stored.
4) The cafeteria and domestic science rooms.

These facilities are often found in the basement of the school. It is apparent that little attention has been given to their segregation and protection.

Heating and cold storage plants should be separate units outside the school building. If they must be included in the building, they should be separated from the rest of the building by fire-resisting walls with an entrance from outside the school building itself. Boiler and fuel rooms should be separated by concrete walls. All doors should be self-closing and fire-resisting.

In manual training shops special care should be paid to electrical wiring and extensions, and to accumulation of shavings, sawdust, paint, and other combustible material.

The above precautions should be taken for cafeterias, and in addition, care should be taken in placing towels or other combustible items on radiators. If incinerators be part of the equipment they should be protected from the rest of the plant with a chimney of sufficient size and thickness.

Combustible materials should not be stored or accumulated in the custodian's room.

Vertical openings such as stairways, ventilating shafts, and spaces between partitions, are perhaps the most frequent ways of carrying fire from one portion of the building to another.

Attics should be eliminated from school building, and if present certainly not used for storing combustible material or carrying unprotected electrical wiring.

Exit facilities should be properly planned. Secondary entrances with double doors should open off the stair landings at intersections of main and secondary corridors. Playgrounds and gymnasium entrances should lead directly from boys' and girls' dressing rooms. Each fireproof stairway should lead directly to an outside exit. All entrances should be free from outside obstruction. All steps should be avoided when possible.

Doors leading from the building should swing outward. At least two pairs of double doors (center mullion provided) should be placed at main entrances. Doors should swing easily, not be too heavy for the youngest or smallest pupil, and provided with fire or panic bolts placed about 3 feet from the floor and being capable of operation by throwing the body weight against them. These bolts should be made so that the arm cannot slip down between the bolt and thereby imprisoning or seriously injuring the child. Automatic catches and stops should be on doors to keep them open when so desired.

Stairways should be continuous from first floor to top story, constructed of fire-resisting material, and enclosed and separated from corridors. Doors leading to stairwells from corridors should be self-closing, of metal and wire glass, smoke-resistive, and should swing with the exit travel. Doors should swing outward on stair landings and in no case upon the stairs themselves. If hand rails be used they should be turned in at the end. Stairways should be not less than 5 feet wide with a 6 or 7 inch riser and a tread of 10 to 12 inches wide maintained for the entire length of the stair. The stairs should be constructed in two runs between floors of approximately the same length (not more than 16 risers to each run). Landings between stair runs should at least equal in width the length of the longest tread. The use of winders in stairs should be eliminated except to connect the gymnasium with the running tract or where stairs are

infrequently used. There should be enough stairs to empty the school building in 3 minutes. Main stairways should have no dead ends and should lead directly to exit on the main floor (which is in line with the stairs). An extra stairway, separated from the main one by a considerable distance should be available for emergency. There should be one stairway, at least, for every 5 rooms. Sharp, right angle corners of walls should be avoided in stairways, and closets for storage should not be placed under any stairway. Ramps are beginning to replace stairs, but their rise should not be greater than 1 to 10.

Corridors should be constructed of durable fire-resisting material and should be as even as possible without change of level. Standard width is 12 feet for main corridors and 8 to 10 for secondary. Lockers in halls should not diminish these widths. Drinking fountains, wash basins, radiators, and other equipment should not project into corridors, and if installed should be recessed.

Outside fire-escapes should not be routed passed windows unless the windows be made of metal frame and wire glass to prevent the fire from breaking through and closing the escape route. Auditorium, gymnasium, and other assembly places where people gather should be planned and located so that exits lead directly to the outside.

Overhead sprinklers should be provided, at least, in dangerous spots. Automatic alarms are important. Regular inspection of fire hoses and extinguishers are important. Regular fire drills should be held.

Summary of Safety Rules

School safety may be defined as the elimination of any possible hazards and proper training of the school child so that injury or death may be prevented. The following standards are some of the more important which should be given careful consideration by all schools:

Good maintenance of buildings and grounds.

Loose boards, splintered floors, cracks, raised boards in floors, broken windows and mirrors should be immediately repaired or replaced and plaster should be smooth and kept in good repair.

Steps within the building and leading to the building should be concrete where possible, kept in good repair, avoiding loose and rotting boards, all edges rounded, and the steps of sufficient width to give a firm tread.

All stairs should be provided with at least one handrail running the full length of stairs, and all elevated porches or stoops should be enclosed with railings.

No protruding nails or other similar objects should be used. Desks should be smooth with wide rounding edges and so constructed that they will not tip or turn over.

School wiring should be frequently checked by an electrician. Damaged wiring, defective switches, fixtures, and the like, should be repaired or replaced.

All broken glass, rocks, cinders, dead tree limbs on trees, old boards, all dead limbs lying on the ground, all hallow trees, weeds, and all refuse, should be cleared and kept cleared from the grounds.

All abondoned wells and other excavations, small holes and washouts should be filled.

Light poles, etc., should not be located on the school playgrounds. Where it is absolutely necessary to place them on the playgrounds they should be protected by suitable padding against contact accidents.

All playground equipment should be of good design and maintained in good repair. Example: Teeter-totter board should be smooth, strong, and well secured.

Foot scrapes should be provided with a guard over them to prevent accidents.

Precautions to prevent explosion, fire and gas poisoning.

Rubbish, refuse, and ashes should not be allowed to accumulate; they should be removed from the school premises frequently.

Mops, rags, and other combustible material should not be stored under stairways, in closets, and other congested places. They should be kept in metal containers with a tight lid.

Fire drills must be held at least once a month.

An efficient means of putting out fire should be on hand. A fire extinguisher is desirable, but if not available, a fire blanket and bucket of sand can be used with good effect. The fire extinguisher should be checked frequently to be sure it is in good working condition.

All exit doors should be equipped with panic locks, and all passageways kept free of obstructions.

Unused matches should be kept in glass jar or metal container and away from any source of flame or children. Used matches should never be dropped in a trash basket. Explosive fluid should not be used to clean or start fires.

All gas appliances must be vented to the outside or to a suitable stack. Horizontal sections of pipes or abrupt turns should be avoided.

Stoves, appliances, and equipment should be kept in good repair and burners and drafts should be adjusted to reduce formation of carbon monoxide. Gas should be burned only in appliances with fixed connections; flexible gas hose should not be used. No appliance should be installed in a room in which the facilities for ventilation do not permit proper combustion under normal conditions of use. Every gas-type appliance should be tested for leaks; and all types of heating equipment tested and adjusted for safe operation.

Poorly constructed flues and chimneys are dangerous and should be repaired or replaced. Heaters and appliances should be adequately supported and so connected to the pipes as not to exert undue strain on the connections.

Physical Activities on the School Ground

A first-aid kit should be in every school.

Children should have a program of organized play on a playground having at least 1,000 square feet per child. Play periods must be adequately supervised by teacher or person alert to the importance of safe play.

In the school the following should be avoided by both children and adults: Running or playing on stairs, running in building, standing on a rocking chair to fix the curtains or adjust a picture, leaning out of windows, keeping feet, books, and other obstructions in aisles, wearing other than proper shoes in gymnasium, not following rules of safety in using apparatus, using defective instruments or machinery, leaving broken glass, scissors, pins, needles, or sharp-edged tools where they are dangerous to children, and handling electric wires and metal pipes at the same time, or handling electric wires while standing on wet surfaces.

School-owner Transportation

Every motor vehicle owned by a public or governmental agency and operated for the transportation of children to and from school, or privately owned and operated for compensation for the transportation of children to or from school, must conform to the Rules and Regulations for the design and operation of school buses. Copies of these Regulations may be secured from the Motor Vehicle Department.

The qualifications of drivers, and the maintenance of buses should be kept at a high level. Bus drivers should have physical examination, and should make daily reports. Buses should be inspected routinely, and chassis specification should meet the school bus standards.

The following instructions to pupils riding school buses should be given careful attention: The driver is in charge of the pupils and the bus. Pupils must obey the driver promptly and cheerfully. The driver will assign a seat to each student. Students in less desirable seats may move to a second assigned seat for added comfort after the passenger load is lightened if permission be first obtained from the driver and if the bus be not in motion. Pupils must be on time, and must never stand in roadway while waiting for the bus. Unnecessary conversation with the driver should be prohibited. Outside of ordinary conversation, classroom conduct should be observed. Pupils must not throw waste paper or other rubbish on the floor of the bus, extend arms or head out of the bus windows, nor try to get on or off the bus, nor move about within the bus while it is in motion. When leaving bus, pupils must observe directions of driver. Any damage to bus should be reported at once to the driver.

Water Supply

The water supply should be an approved city supply where possible; well, spring, or cistern must be protected according to the Department of Health specifications. There should be proper drainage for all waste water, and there should be no cross-connections between the drinking water supply and any other water or waste system. For details on a safe, potable water supply see other pertinent chapters.

Drinking Facilities (see chapter on Plumbing)

The drinking fountain must be approved by the Health Department. The height of fountains should accommodate all children, and step like elevations should be used when necessary. There should be one jet for every 50 pupils up to the first hundred, and one for each hundred thereafter.

When pressure water is not available a fountain supply tank of impervious non-oxidizable material may be used. It should be placed where easily accessible and cleaned; should have overlapping top; should be thoroughly cleaned each month. Water should be disinfected with chlorine after each filling and kept at less than 75° F. If ice be used it must be of sanitary quality and handled sanitarily.

Water from spring, well, cistern, or other approved source which is dispensed by cup, should be collected, stored, and dispensed in sanitary manner. If cooler be used, the same technique as for tank applies. Single-service cups are desirable, but if individually owned cups be used, only the owner should use his cup.

Showers, Locker Rooms and Swimming Pools (See chapter on Swimming Pools and Bathing Places.)

Handwashing Facilities

Lavatories should be conveniently located near the toilet, preferably in a room leading to the toilets. Hot and cold water, soap dispensing equipment for powdered and liquid soap, and paper towels should be provided. Soap dispensers should be placed directly above lavatory. Soap jelly may be used.

Lavatories should be made of vitreous china with all-metal self-closing faucets. Hot and cold water outlet should be supplied for floor washing. An individual ventilating system should be an integral part of the lavatory and toilet. In kindergartens and elementary grades, lavatories may be in play or class rooms under the teacher's supervision.

Slop sinks may be conveniently located in connection with toilet and lavatory rooms, preferably in separate closets sufficiently large to store mops, brooms, and other cleaning material.

Formula for making liquid soap is as follows: One medium sized cake of good soap chipped and dissolved in two cups of hot water. When soap is dissolved, six cups of warm water should be added and vigorously stirred.

Paper towels are preferred. If individual cloth towels be used, they should be stored in a clean manner. The following procedure is recommended:

A line should be provided for drying during the noon hour, and each child should pin his towel on the line with a slip type clothes pin on which his name is written.

When the lunch hour is over each child places his towel in a folded paper and clips his pin on same.

The towel is then stored in his desk or on the lunch shelf.

Handwashing Procedure for Schools without Plumbing

Equipment: (a) Two large pitchers or coffee pots, or bucket and dipper for pouring water. (b) Container of liquid soap —a sprinkler top bottle or large oil can. (c) Liquid soap. (d) Individual paper towels preferred. Towels made from flour or sugar sacks are acceptable. (e) Two or more buckets, or small tub for waste water, placed high enough to prevent water from spattering.

Personnel: (a) Soap Monitor, (b) Water Monitors, (c) Towel Monitors if paper towels be used.

The pupils form in line, passing the soap monitor first who sprinkles a few drops of soap on the hands. Then the water monitor who stands back of the waste water receptacle pours carefully a small quantity of water over the hands. The pupils dry their hands and pass to their seats to eat lunch.

Toilet Facilities

Toilets should be conveniently located with separate rooms for sexes. They should have outside exposures and receive ample direct sunlight. Basement toilets should be avoided due to lack of sunlight, difficulty of ventilation and cost of sewer connections. In kindergartens toilets may be adjacent to play or class room. Toilets should have good ventilation either by windows or forced air removal. The walls should be painted a light color.

Where septic tanks are used, the septic tank capacity should be about 15 gallons per capita for the school population. In elementary schools there should be enough low toilet seats, i.e., 13 inches high, for the small children (See subsequent regulations).

Safe Plumbing. No cross-connections should exist between drinking water supply and supply of other sources. Lavatories and toilets should be properly protected against back-siphonage.

Maintenance. For privies, the door, lids, seats, and mount should be kept in good repair; fly-proof. Floors and seats cleaned daily. Inspection daily by monitors (one boy and one girl) or by the teacher to see that the toilets are not abused, used properly, lids closed, kept clean, and supplied with toilet paper.

Toilet Paper. An ample supply of good quality should be provided and the use of catalogues, newspapers, etc., should be discouraged.

Paint for privies may be regular outside paint, or stained with a mixture of cresote and crank case oil.

Sewage and Refuse Disposal

Methods of sewage and refuse disposal should be in accordance with provisions recommended in any modern sanitary code. See chapters on "Sewage Disposal" and "Refuse Disposal."

Food Equipment

Where any food or beverage is sold in the schools, the equipment should be sanitary and the techniques and standards for handling, storing, processing, and distributing should be in accordance with the provisions under regulations for Food Handling.

School Lunch Room. In recent years the Federal Government has encouraged the provision of school lunches by financial subsidied and distribution of surplus commodities thru the National School Lunch Room Act of 1946 which is administered by the Production and Marketing Administration of the Department of Agriculture. Officially sponsored and supervised lunch rooms have a definite and permanent place in the educational system for the following reasons:

1) The school authority is the ward of the child during the attendance period and therefore has the responsibility over the general health of the child. That a large section of the school children are malnourished has been demonstrated over and over again. The school lunch is therefore as essential a protective measure as good sanitation.

2) The school is the place where good eating habits can be and should be taught the child as well as writing, reading, and arithmetic. The teachers should therefore be present during the lunch period and even eat with the children in order to supervise and to serve as an example.

Food is prepared in a sanitary manner and all dishes and utensils properly washed, sterilized, and stored. A hot lunch should be provided in the cooler months.

Following is a list of the minimum equipment for schools preparing and serving lunch. Very simple materials and techniques are required for serving one hot dish in a one-teacher school. which are as follows:

- Storage space
- Screening
- Means for sterilizing utensils
- Means for cleanliness and garbage disposal
- Stove for heating food
- Four gallon kettle
- Dipper or ladle
- Long-handled wooden spoon
- Dish-washing equipment
- Wash basin
- Towels
- Two dishpans
- Fingernail brush
- Wash cloths
- Kitchen linen or paper substitute
- Wire rack
- Quart measure
- Two paring knives
- One tablespoon
- Cup or bowl and plate for each child
- Chlorine
- Tray
- Soap and detergent
- Box for storing dishes
- Box for teaspoons and tablespoons
- Ice box for perishable food

Source of Food

The source of the school food supply may be from the regular source supplying the community Schools may, however, raise their own fruits and vegetables, produce their own milk and meat, and process and store these foods for future use. Schools may also receive food from Federal Government surplus commodities. Then again they may receive food from local donations. Whatever the source of food may be, the quality and handling must in all cases conform with the sanitary provisions recommended for any food to be used for public consumption.

Handling Procedure of Hot Lunch Program

In general, the handling procedure for hot lunch programs should encompass all the sanitary practices that apply to restaurants with whatever adjustments are necessary to fit the school situation.

Where refrigeration cannot be provided, perishable food left over should be disposed by sending it home with the children or put into garbage the same day it is prepared.

Food handler supervision should be same as for commercial establishments and so should the equipment and the condition of the kitchen.

Food must be of good quality, not fermented, decomposed, frostbitten, unclean nor contaminated.

Milk should be pasteurized. If unpasteurized, it should be boiled on the premises. If powdered milk be used, it must be fixed with safe water within an hour of the time to be used. Milk, when stored, should be maintained at 45^{o} F. or lower.

Home canned fruits are usually safe, but home canned meats and vegetables may be used only after being boiled for 15 minutes after removing from can without tasting. Tasting, when cooking, should be done with a separate spoon.

Even where refrigeration is provided such foods as contain cream fillings, meringues, custards, non-acid dressings such as salads made with mayonnaise, Hollandaise cream or cooked dressing, and hash or other ground and left over meat dishes, except smoked or cured meats should not be kept over for the next day.

The kitchen must be kept free from flies, mice, rats, roaches and other vermin, and matches kept safely in a tin or glass jar with tight fitting cover.

Food must be kept in closed, dust-proof and vermin-proof containers, and so must garbage be so kept. Staple foods should be stored in metal or glass containers.

The following basic sanitary practices should be stressed:

Personal hygiene practices for food handlers must be carried out, such as, being free from sickness or sores on hands, washing hands after every use of toilet, having clean finger nails and clothes, wearing hairnets, not coughing or sneezing into food, no smoking on the job, etc.

Sanitary equipment and handling of food as discussed in other chapters of this book on food control should be adhered to.

Routine Procedure for Dishwashing

1. Before washing dishes, hands should be cleaned in soap and water, and nails scrubbed thoroughly with fingernail brush.
2. To remove all particles of food, dishes should be washed in warm water (115° F. to 120° F.) containing one teaspoonful of detergent for each gallon of water.
3. Dishes should be rinsed in bactercidal solution and allowed to stand for one minute completely submerged, or scalded with water over 170° F. for two minutes or with boiling water for 1/2 minute.
4. Dishes should be placed in wire rack to dry. They should not be dried with a cloth.
5. Dishes should be removed from the rack when dry and placed in dust-free and flyproof cabinet or container.
6. Where no waste water drains are available, waste water should be disposed of away from school building.

Home Prepared Lunches.

Where school prepared lunches are not yet available, the following technique may be used to heat and supervise the lunches brought from home by the children:

Storage. Food brought from home may be stored in child's locker. But the food must be well packaged to prevent crumb or liquid spillage. A screened cupboard may be provided where individual lockers do not exist. Storage of all perishable foods, including certain sandwiches, should be in refrigerated facilities capable of maintaining such food at 45° F.

Supervision. Children may be seated on playground during summer months; in winter in the building, and in all seasons timed and supervised by the teacher. This helps to prevent such evils as fast eating, the exchange of partly eaten food, handling soiled articles, etc.

The Hot Jar Lunch Method. The pupil brings his regular lunch, in a box, basket, or bucket. His cooked food, such as cocoa, soup, stew, fruit, vegetables (beans, peas, corn, etc.) should be contained in a half pint screw top jar.

The School Provides a flat stove, electric plate, or oil stove, a boiler, lard can or kettle with tight fitting top, large enough to hold the half pint jars, and perforated tin or wooden racks to place on the bottom of the kettle and between the layers of jars.

Preparation, by Teacher or Lunch Monitors, at the Morning Recess:

The teacher or lunch monitors assemble the jars near the stove, pour about two inches of cold water in the kettle, place the jars in order, with tops lightly screwed, fasten the lid of the kettle tight, and set the kettle on the stove.

The procedure for serving the lunch consists of the pupils washing their hands before eating,

the monitor or teacher distributing the jars to their owners taking care to protect the hands and arms against steam burns, the children seating themselves at their desks, putting paper or other covering on the desk before spreading the lunch and eating in an orderly fashion, monitors cleaning up any paper or trash, and taking the jars and spoons home to be washed.

Housekeeping

Although most of the housekeeping be usually performed by custodial workers, it is the duty of the school administrator and the teachers to take an active interest in the tasks of the custodian and show a cooperative attitude toward custodial efforts. In general, those responsible for cleaning should have suitable training and experience and should work under the supervision of the school administrator. The housekeeping routine should be definitely outlined.

Schedule for School Housekeeping

General cleaning instructions. Those responsible for cleaning but unable to report for duty should notify supervisor as soon as possible. All major repairs, alterations, and new facilities needed should be reported to supervisor. Inventory of supplies should be continuously available.

Daily Duties. This consists in keeping sidewalks and grounds clean, wastebaskets emptied, floors, carpets, lavatories, toilet, mirrors and cloakrooms clean, furniture, counters, rails, chalk rails, sills, desks, chairs, etc. dusted, and all refuse collected and disposed.

Weekly Duties. This consists of disposing of all trash, paper, debris, etc., dusting venetian blinds, shades, and high places, washing floors and baseboards.

Monthly Duties. This consists of dusting walls, cleaning light fixtures and globes, removing marks from walls, and washing windows.

School Sanitation Regulations

Legal provisions with regard to the administration of school health activities vary in different states. Sometimes the administration of this work is vested by law solely in the school authorities, sometimes in the public health authorities, and sometimes divided between these two. Whatever the case may be, a local health officer has the right to enter a school at any time for the purpose of investigating cases or suspected cases of communicable diseases, nuisance or any other conditions that are or may be dangerous to the public health. In order to obviate difficulties between the health and education authorities, it would be wise that sanitary regulations for schools be developed by the cooperative reasoning and agreements of these two authorities.

The following regulations were developed by the Engineering Section Project of the American Public Health Association as part of the Proposed Sanitary Code for Louisville and Jefferson County, Kentucky.

General Provisions

The following definitions of terms shall apply unless the context clearly indicates another meaning or unless elsewhere expressly stated for specific application.

The term "school" shall mean an institution offering training facilities for teaching children or offering instruction to children in any branch of knowledge and shall include schools known as public schools, private schools, parochial schools, elementary schools, vocational schools, trade schools, grammar schools, graded schools, high schools, and any such institution intended for the teaching of children and offering instruction ranging from that of a primary grade to that equivalent to 12th grade or high school training on a class room or similar organized basis.

The term "kindergarten" shall mean a school conducted for children of less than primary grade age.

The term "nursery school" or "day school for children" shall mean a school conducted for very young children and shall include kindergartens not attached to or operated as a part of a school as defined above and all other supervised organized training facilities for children of preschool age.

Approval of Plans

(For new construction or alteration of existing structures, the regulations are the same as for all public buildings in relation to obtaining approval from the health department.)

Protection, Supervision, Maintenance

General

All school premises including the structures shall be maintained in a manner complying with the standards and requirements hereinafter provided and all applicable provisions of the sanitary code.

The health officer shall hold the responsible head of any institution responsible for any non-compliance with the sanitary code.

The responsible head shall be, if not designated otherwise by law, the superintendent of a public school; the owner and/or manager of a private school; the person or persons specifically named to the health officer by a parochial school organization, or if not named the person charged with the responsibility of headmaster; or the superintendent of an elementary institution conducting a school.

When any portion of a school conducts an operation which requires operating or occupancy permits under the provision of any chapter of the sanitary code, the responsible head shall apply for, obtain, and hold an unrevoked operation or occupancy permit for that purpose. Specific operating permits are required for: A dairy or milk plant, a food establishment, a swimming pool or bathing place, a semipublic water supply or water supply transportation or distribution, a semipublic sewerage system. Specific occupancy permits are required for: Dormitories, multifamily or single family dwelling units leased, rented or occupied by other than employees of the school and their immediate family, places of public entertainment or amusement.

Any kindergarten operated as a part of or in connection with a school shall meet the requirements for child care schools set forth in this Code, in addition to the requirements for schools as established in this Chapter.

Investigation of Schools

The health officer shall make or cause to have made such surveys, investigations, inspections and visits as may be deemed necessary to ascertain compliance with the sanitary code in all schools within his jurisdiction.

Every school shall be officially inspected and rated not less than once each year, and more frequently when the conditions found are such as to require closer supervision to protect the health of the school children.

(The regulations are the same as in other parts of the Code for collection of samples or specimens for analysis, permission to enter school premises for investigations, giving copy of inspection findings to responsible head.)

Whenever any school fails to make required corrections within the time limit required, or fails to make improvements recommended in accordance with two successive official inspections, the health officer shall render a full report of the conditions, the recommendations made, and the action or lack of action in connection therewith to the state health department and the state superintendent of schools.

If, 60 days after the submission of the report above, no evidence has been submitted by the responsible head of the school to show progress in the correction of the deficiencies noted in the report to the state officials, the health officer may notify the parents of all pupils attending such school of the deficiencies noted and the recommendations made, and may, if deemed advisable, publicize the conditions found at the school.

Records

The responsible head of a school, and all employees under his supervision shall furnish to the

health officer or his agent such records, information and reports as may be required to ascertain the status of compliance with the sanitary code, or the ability of the premises to comply with the sanitary code.

Standards

General

Every school shall comply with the standards and requirements as set forth hereafter.

Every school shall meet the standards and requirements in any portion hereinafter constructed, altered, extended, modified, or changed.

Every school now existing shall conform with written recommendations by the health officer establishing minimum terms and conditions and a time limit for compliance.

Every school now existing shall offer competent evidence that all feasible and practical efforts are being made to comply with all written recommendations issued by the health officer establishing terms and conditions for compliance with the standards, but not containing a time limit. Such evidence shall consist in part of:

Estimate of cost of work to be done obtained within three months after the date of the recommendation.

A financial statement supporting any statement that the work cannot be done due to lack of money in the current budget.

A statement of any work started or completed within six months after the date of the recommendation.

A statement indicating a provision in the next year's budget for all or a substantial portion of the work to be done.

Satisfactory Standards

Floors

The floors of all the rooms shall be adequate in size, properly insulated, of easily cleanable material; shall be smooth, in good repair; proper cleaning methods shall be employed systematically after school hours; and floors shall be kept clean.

A minimum of 15 square feet of floor space per pupil shall be available.

Floors of all the rooms in the schools shall be of such construction as to be easily cleaned, smooth and in good repair. Floors may be of concrete, terrazzo, tile, matched hardwood, or equal composition and shall be waxed when practicable.

Floors in toilet rooms shall be of impervious material.

Wooden floors containing cracks, holes, broken or poorly fitted planks containing slivers, or which otherwise fail to be tight, shall not be permitted.

Dustless methods of floor cleaning shall be used, or dust arresting sweeping compounds and push broom employed.

The application of oils directly to the floor in excessive amounts is prohibited.

All except emergency floor cleaning shall be done after school hours.

Provision shall be made to keep floors dry near water fountains and handwashing facilities.

All floors shall be kept clean and free from litter. Each room shall have at least one metal container for paper and trash.

Walls and Ceilings

The walls and ceilings shall be smooth, tight, and in good repair. Walls and ceilings shall have surfaces of light color and flat finish. Walls and ceilings shall be kept clean.

Walls and ceilings in all the school rooms shall be tight, smooth, and in good repair. Beaded wainscoting shall not be used for walls or ceiling material.

Ceilings and overhead structures shall be painted as light as practicable and shall have a reflection factor of at least 80 percent.

Upper walls shall be painted a light color, and walls adjacent to window areas shall be as near white as practicable. The reflection factor shall not be less than 50 percent, and preferably 60 percent.

Lower walls up to the dado line and not more than 1/3 of the height shall be a darker shade than the upper wall, and shall have a reflection factor between 25 percent and 40 percent.

All wall and ceiling surfaces shall have a flat non-glare producing finish of washable paint.

Walls shall be clean.

All window and door glass, frames and shades shall be clean.

All painted surfaces shall be refinished as often as may be necessary to maintain a smooth, clean surface, free from cracks and holes.

Screening

When flies are prevalent, all openings to the outer air shall be effectively screened and doors shall be self-closing, unless other equally effective means be provided to prevent the entrance of flies.

All openings to the outer air shall be effectively screened with not less than 16 mesh wire or plastic cloth; and all doors shall be self-closing, free-swinging, and outer doors or screen doors shall open outward.

When entrance doors swing outward, are self-closing, and are kept closed, screen doors will not be required or if a screen door be used in hot weather the outer door may be removed.

Screens for windows, doors, and other openings including skylights, ventilators, transoms, stovepipe holes not in use, shall be tight fitting and free of holes.

The interior shall be kept free of flies at all times.

Screening shall be used throughout the fly breeding season of the year.

Illumination

All rooms must be sufficiently lighted to permit good housekeeping.

Lighting shall be properly distributed. Shadows, glare and extreme contrast shall be absent from all surfaces.

Direct rays of sun shall be controlled by shades or blinds of a design acceptable to the health officer.

Windows shall extend as near to the ceiling as possible and shall be located along one side or two adjoining sides of the study room.

The total window area shall be not less than 1/5 of the floor area.

All windows in class or study rooms equipped with roller shades shall have adjustable shades

of light-colored, translucent material. Such shades shall be mounted on two rollers near the middle of the window opening, one operating upward and one operating downward.

Venetian blinds, employing reflecting and diffusing surfaces which may be adjusted at various angles, are satisfactory.

All classroom windows shall be provided with light shields, shades, or blinds which shall be kept in good working condition and so used or adjusted that glare and excessive light intensities are reduced to a minimum.

Window panes shall not be used for decorations or objects which shut out the light.

Artificial lighting shall supplement daylight so that high-level, well-diffused, glareless illumination be available at any hour of the day, any day in the year.

Unshaded and unfrosted or uncoated electric bulbs are prohibited excepting in direct lighting fixtures.

Whenever electricity is available, the study or class room shall be artificially lighted at all times that natural lighting is insufficient to provide a proper amount of illumination and uniform distribution throughout the room.

There shall be at least 30 foot-candles of illumination measured by an accurate light meter on the top of each study desk.

Desks shall be rearranged when necessary to provide sufficient lighting.

Additional lighting for difficult seeing tasks shall be provided when required by the health officer and shall be not less than 50 foot-candles for sewing benches, laboratory benches, manual training and shop work benches. The health officer shall be guided by American Standard Practice for School Lighting as established in the code of that name: A.S.A. 23. 1-1948.

Hallways shall be lighted with not less than 5 foot-candles of illumination when in use.

Storage rooms shall be lighted as required for special uses.

Heating

All rooms of the school shall be properly heated so that the inside temperature 4 feet above the floor does not fall below 68 degrees F. The ventilation shall be sufficient to provide adequate oxygen, a character of freshness in the air and to remove exhaled air and undesirable odors.

Heating equipment shall be adequate to maintain temperatures evenly throughout the classroom at not less than 68 degrees F. Radiators, stoves, ventilators, duct openings, registers, or other heating devices and appurtenances shall be so located and installed that such uniform temperatures can be maintained and shall be of a type acceptable to the health officer.

Combustion type fuel-fired heating units located within a school room shall be fitted with a metal jacket of such character that air may circulate around the exterior surface of the stove combustion chamber, and so that pupils are protected against direct radiant heat from the combustion chamber walls. Such stove shall be located near a corner or a window and shall not have a vent stack inside the room longer than 7 feet.

Any vent or stack leading from a heating unit shall be absolutely tight at the joints so that under no circumstances can fumes, smoke, or unburned gases pass from the heating unit or vent stack into the room.

Each room shall be furnished with an indicating thermometer of a type acceptable to the health officer. The thermometer shall be accurate within 2 degrees F. between 50 degrees and 80 degrees F.

Automatic thermostat control thermometers shall be checked weekly with an indicating thermometer during the heating season. Rooms not heated by thermostatically controlled heating units shall have a temperature check four times daily during the heating season.

All check thermometer readings shall be kept on an acceptable record form available to the health officer at any time.

A temperature variation of more than 5 degrees in any part of the room when measured at a level 4 feet above the floor shall be considered as non-compliance with uniform temperature requirements.

The maximum temperature in any class room during the heating season shall be 76 degrees F. The heating season is that period of time during which temperatures within the building may fall to 65 degrees F. unless heating equipment be used.

During the heating season the air shall contain a sufficient amount of water vapor to avoid dryness. The relative humidity shall not be less than 30 percent nor more than 60 percent and 50 percent shall be considered optimum. Relative humidity shall be checked at least once in the morning and once in the afternoon in all rooms not provided with a means of regulated humidity control.

Ventilation

Ventilation shall be considered by means of windows, ventilators, louvers, and such mechanical equipment as may be necessary to secure adequate quantities of air, and to control the movement of air within a room.

Direct currents of air shall be absent. When ventilation is furnished by open windows, the windows shall be equipped with metal ventilators or glass deflectors acceptable to the health officer. When windows are the only means of ventilation at least 1/2 the windows shall open from both top and bottom and shall be so controlled that there will be vertical distance between adjacent openings.

The capacity of a school room shall be at least 200 cubic feet of air space per person and any room containing more persons than capacity calculated on this basis is deemed to be without adequate ventilation.

In rooms provided with mechanical ventilation there shall be an air exchange equal to 30 cubic feet per person per minute. The replacement of vitiated air with outside air shall be sufficient to maintain a room atmosphere free of odors and normally may be between 10 and 20 cubic feet per minute per person. Return vents and registers shall be so designed that direct air currents caused by excessive velocities be avoided.

Toilet Facilities

Each school shall be provided with adequate and properly located toilet facilities. The doors of all toilet rooms shall be self-closing. Toilet rooms shall be kept in clean condition, in good repair, well lighted and ventilated. In case privies or earth closets are permitted and used, they shall be of a sanitary type, constructed and operated in conformity with the standards of the sanitary code.

Toilet facilities shall be provided in the following ratios:

Type of fixture	Equivalent Grades of Pupils	Ratio based on Capacity of School	
		Boys	Girls
Toilet stool	8th or less	1:100 or fraction thereof	1:35 or fraction thereof
Toilet stool	9th to 12th	1:100 or fraction thereof	1:45 or fraction thereof
Urinal	12th or less	1:30 or fraction thereof	- - - - - - - - - -
Lavatory	8th or less	1:60 or fraction thereof	1:60 or fraction thereof
Lavatory	9th to 12th	1:100 or fraction thereof	1:100 or fraction thereof

Each toilet stool shall be in a partitioned space protected by a self-closing partition door. Toilet partitions shall begin not less than 1 foot from the floor and extend to a height of not less than 5 feet.

Lavatories shall be installed at heights convenient for the use of the pupils, and in schools having grades below the 4th, there shall be the number of washbowls required for the school capacity in the category installed 12 inches lower than standard.

The same provision as for lavatories shall be applied to boys' urinals for grades below the 4th, when other than stall type urinals extending to the floor are provided.

The toilet room shall be provided at all times with an adequate supply of soap, sanitary towels, and toilet paper. The toilet room shall have illumination of not less than 5 foot-candles available at all times of use. The toilet room shall be ventilated to the outside air.

All toilet rooms shall be kept in good repair, clean, free of litter, and free of splashed or overflow water at all times. Toilet rooms shall be cleaned, scrubbed, and disinfected once daily and more often if required for the maintenance of clean conditions.

Each toilet room shall be provided with metal containers with swing covers in which shall be placed and kept all discarded articles and paper towels pending custodial collection.

All toilet rooms shall be plainly identified and marked with signs designating the sex for which such room is intended.

All fixtures and toilet seats shall be of impervious material and free of cracks or holes.

All toilet rooms shall have durable legible signs posted conspicuously directing students to wash hands after each use of the toilet and establishing rules concerning the use and care of the toilet room.

Privies shall be prohibited on any school premises having available or procurable a supply of water of 10 gallons per capita per day under pressure, and on any premises with an enrollment capacity of 200 or more.

Privy toilet seats shall be of impervious material and free of cracks or holes. Privy urinals shall be porcelain, metal, or concrete or other impervious material,and if trough type,2 feet shall be provided for each urinal required. Privies shall conform to the requirements established in this Code.

Each lavatory on premises having running water under pressure shall be supplied with hot and cold water, and each lavatory on premises without running water under pressure shall be supplied with water from a container in a sanitary manner acceptable to the health officer.

Handwashing facilities additional to those specified above, shall be provided in all rooms where activities are of a dirty or hand-soiling nature and in the first grade rooms; and shall be provided in manual training or shop rooms, cooking class rooms, laboratory rooms, and all similar places.

Whenever toilet handwashing facilities are not a part of the toilet room, the required number of lavatories shall be installed in a room or place approved by the health officer and shall be kept clean and in good repairs.

Water Supply

The water supply for the school shall be properly located, protected and operated, and shall be adequate and from an approved source. The water shall meet the requirements established in this Code. Buckets are prohibited for transporting water.

Drinking water shall be provided and dispensed by means of a drinking fountain or other dispenser approved by the health officer. Drinking fountains shall be provided in the ratio of one per

each 50 students or fractional part thereof.

Sanitary single use containers stored and dispensed in a sanitary manner shall be provided for use at drinking water outlets other than fountains, and metal watertight waste containers shall be adjacent such dispensers to receive waste containers.

All outlets or fountains shall be convenient and accessible to the students to be served, and shall be lowered 12 inches for the use of students below the 4th grade or shall have a safe convenient step-up to such fountains as may be required for the number of such students to be served.

The plumbing system as defined in this Code shall be complied with.

The Building and Premises

The building shall be located, constructed and maintained to protect the health of the students. The school grounds shall be of sufficient size, topography, cleanliness, and arrangement to encourage wholesome recreation.

School premises and buildings shall be located on well drained ground, above unprotected flood levels, and away from all known normal hazards of inundation.

Buildings shall be so placed that ground drainage is away from buildings.

No portion of a building cellar shall be used for class room, recreational, or physical education purposes. Basements of buildings may be used by students in grades above the 8th when specifically approved for such purpose by the health officer.

The building shall not be located on a hazardous hill or on swamp land.

The buildings shall be so located, designed and constructed that a maximum of sunlight can enter the rooms.

School buildings shall be easily accessible from streets, walks and public ways or other school buildings by well drained hard surfaced walks not less than 3 feet wide. Weather-proof walks shall be provided to the street or highway, to outdoor toilets, water supply, fuel house, etc. These walks may be made of any suitable material which will not become muddy in wet weather such as cement, gravel, or cinders. If gravel or other loose material be used, provision shall be made to keep material from scattering.

School buildings shall be located away from dust, noise, gases, soot, and heavy traffic.

The school building shall have a substantial and enclosed foundation and a watertight and fire-resistant roof. Consideration should be given to protection from lightning when school is in an exposed location.

The chimney or flue shall rest on a solid ground and shall extend not less than 2 1/2 feet above the highest portion of the roof ridge of the building.

The buildings shall be rat-stopped, and rat-proofed in accordance with the provisions of this Code.

The premises shall be free of mosquito breeding areas,or such areas shall be controlled in accordance with the provision of this Code. The premises shall be free of vermin.

The area composing the playground, as well as that immediately adjacent to the school building, shall be evenly graded and sloped so as to provide adequate surface drainage. Under-drains connected to public drains shall be installed and shall operate properly when necessary in large level areas or where soil conditions do not provide sufficient natural drainage.

Ample area shall be provided. The play area shall be either fenced or properly isolated from heavy vehicular traffic. A minimum of 25, 000 square feet must be provided for any playground.

Approximately 1,000 square feet of usable play space is recommended for each child. The school ground shall be kept free of debris and high weeds.

Classroom Equipment

Construction, repair and location of classroom equipment shall be such as to permit approved use. Erasers, crayon trays and furniture shall be kept clean. Blackboards and furniture shall be of a dull finish.

The material used for the blackboard shall be slate, composition, glass, or equal construction. The blackboard finish shall be smooth and there shall be no cracks and as few seams as possible.

All blackboards which are to be refinished shall be thoroughly sandpapered to remove all rough places and shall be given two coats of standard finish. The finish shall be dull black or dull green or white.

The blackboards shall be installed opposite windows and so located that they will be seen by the intended user easily and without extreme light contrast. The blackboards shall not be located in narrow spaces between windows or on a windowed side of a room.

Blackboards must extend to within 24 inches of the floor for primary grades, 28 inches off the floor for intermediate grades; and 32 inches off the floor for upper grades.

The blackboard erasers and crayon trays shall be clean. Crayon or chalk shall not contain lead, lead compound, or dangerous soluble methyl bromide dyes.

Each student shall have an individual seating unit with writing table attached or adjacent to the seat so constructed as to provide comfortable seating and convenient writing without undue strain.

The desks shall be so arranged that the light is admitted from the left and rear of the seated children. Special consideration should be given to the left-handed children. Their desks should be so located that light will be over the right shoulder.

When the pupil is erectly seated with feet squarely on the floor, there must be no pressure from the forward edge of the seat under the knees.

The height of the writing surface should be such that when the pupil is erectly seated, shoulders well down and elbows fairly close to the sides, with palms flat on the desk, both forearms in writing position will contact throughout the surface.

The furniture shall be kept in good repair and the desk tops shall be of a smooth, dull finish and shall be kept clean. Desk tops shall be finished in natural wood finish and shall offer as little contrast when compared with white paper as is practicable. Painted desks shall be finished in a light color approximating natural wood finish.

Lunches shall be stored in a clean, dry place, protected from flies and other contamination, and shall be in storage located outside the class room in a well lighted and ventilated space. The general school supplies shall be stored to comply with good housekeeping. Individual service containers, if used, shall be handled and stored in a sanitary manner. Combustible or poisonous material must be stored in a manner affording protection to the children. Home lunch storage shall be in a clean dry place protected from flies, other vermin and other contamination.

Sufficient storage space shall be provided to store outer clothing, rubber, play equipment, etc. This space shall be easily accessible, well lighted and ventilated, and shall be so located that it can be supervised by a teacher.

All school supplies shall be stored in a manner to protect the children.

All lunch papers, food scraps, and other debris resulting from the eating of home lunches shall be collected, cleaned up and deposited in suitable metal receptacles with tight metal covers. The floors of such rooms or lunchroom spaces shall be cleaned properly every day after the

lunch hours.

All waste shall be properly disposed of and all garbage and trash will be kept in suitable receptacles, in such manner as not to become a nuisance. All liquid wastes shall be disposed of to a public sewerage system as provided in this Code, if such be available to the school premises.

If a public system be not available, the liquid wastes shall be disposed of in a semipublic sewerage system conforming to the provisions for such system established in this Code.

All garbage shall be collected in metal containers having tight fitting metal covers and shall be of a type acceptable to the health officer. Garbage receptacles shall be washed and treated with a disinfectant as often as may be necessary to prevent nuisance, and in no event less than once per week.

The disinfectant used in such containers shall contain at least 50 ppm. of chlorine or its equivalent of an acceptable bactericide.

All garbage, trash, and other solid wastes shall be disposed of in a manner conforming with the requirements established in this Code.

Combustible wastes, paper, and similar materials shall be collected, handled, and stored pending disposal in containers located so that a fire hazard is not likely, and in a manner acceptable to the health officer and the fire prevention bureau having jurisdiction.

All schools shall have adequate first aid facilities, fire protection and fire extinguishers. The play area shall be a safe place for the children to play.

Each school building shall have first aid material available and easily accessible. It is recommended that first aid kits be equipped with the following items:

Rubbing alcohol
Ammonia, aromatic spirits of U.S.P. (4oz.)
Applicators, throat, wooden
Bandage, gauze, 1-inch (10 yd.) (sterile)
Bandage, gauze, 2-inch (10 yd.) (sterile)
Bandage, triangular
Cotton, absorbent, sterile (1/4 lb.)
Cups, drinking, paper
Dressings, finger, 3/8-inch, band aid
Dressings, finger, 1-inch, band aid
Gauze, sterile (1 sq. yd.)
Gauze, sterile, plain, pad 2x2 inches, in germproof envelope
Gauze, sterile, plain, pad 3x3 inches, in germproof envelope
Oil of cloves (1 oz.)
Petrolatum, plain, white (2 oz.)
Pins, safety, No. 2-1/2, 1-1/2 inch
Soap, green tincture, U.S.P. (8 oz.)
Splints, for arm, 3x17 inches-Yucca No. 1 or equivalent
Splints, for leg, 3-1/2x30 inches-Yucca No. 1 or equivalent
Splints, for thigh, 3-1/2x20 inches-Yucca No. 1 or equivalent
Tape, adhesive, 1/2 inch (10 yard)
Tape, adhesive, 2-inch (10 yard)
Tape, adhesive, 1-inch (10 yard)
Thermometers, clinical, Fahrenheit
Tongue blades
Toweling, paper, 10 inches wide
Toweling, paper, approximately 30x40 inches, 1/4 fold
Scissors
Forceps, splinter
Forceps, dressing
Hot water bottle
Icebag
Washbasin
Dressing Basins
Inelastic tourniquet
Tooth picks
Red Cross First Aid Textbook

The Red Cross First Aid Manual (current edition), and the Boy Scout Handbook are recommended as guides on technique.

At least one manually-operated fire extinguisher shall be provided in each school building on each floor and so located as to be easily accessible. A carbon dioxide or 2 1/2 gallon soda and acid chemical extinguisher or a 5 gallon water extinguisher with pump or other approved type will be acceptable. Each fire extinguisher should be periodically examined and kept at all times in a usable condition.

School buildings which are two or more stories in height must be equipped with standard fire escapes which meet the approval of the fire prevention bureau having jurisdiction.

All doors to the outside must open outward and shall be equipped with panic latches.

Fire drills shall be held at regular intervals and not less than once a month. Fire drills should be worked out so that the element of surprise is taken into account.

The play area shall be such as to make a safe place for the children to play. There should be no rocks or obstructions in the area and the ground should be leveled. If the playground be situated near the road, a safety fence shall be provided.

All playground equipment shall be well constructed and maintained in good repair. The equipment shall be inspected frequently to detect defects and when found shall be dismantled or placed out of service until repaired or replaced.

No hazardous condition shall exist on the premises whereby or as a result of which a person may slip, trip, fall, be gouged or pierced by sharp or jagged object, or burned, or shocked by electricity, or exposed to any toxic substance, or in any way be subjected to a hazard to health or life. All feasible and practicable means shall be taken to eliminate such hazards.

Every school which serves a hot lunch, or a hot meal or food of any kind under school supervision with or without the assistance of a voluntary organization shall conform to the requirements in that portion of the premises used for such service or preparation of food established in this Code.

Whenever any school is provided with a gymnasium, or other such place used for supervised physical education and exercise, or an athletic field or any other place where students are required to dress, undress, or change into special clothing, for the purpose of engaging in physical exercise, there shall be provided adequate, sanitary, dry and clean change room facilities, lockers for clothing, shower, toilet and wash room facilities, and all necessary appurtenances thereto.

Such change rooms shall conform to the requirements of change room facilities required of bathing places in this Code, unless a specific exemption be granted by the health officer.

Exemptions shall be made only when under all the circumstances and conditions it is not practicable and feasible to maintain the standard above. Under no circumstances shall an exemption be granted which will expose any person using the change room facilities to an unnecessary hazard to health, or to disease, or to personal injury.

Whenever a school bus shall be operated for the purpose of transporting students to and from a school, the school bus shall be clean, properly ventilated, properly licensed, and safe to operate on the highways. The bus driver shall hold a valid certificate from the health officer certifying his physical condition as satisfactory for the purpose of driving a school bus. Such certificate shall be granted only to those persons meeting the health officer's requirement for: Satisfactory hearing and vision, freedom from dangerous cardiac and vascular infirmities, satisfactory reaction time and muscular coordination, satisfactory extremities of hand and foot, and freedom from any impediment or habit which would be likely to cause unsafe driving.

The bus driver shall have passed within one year a driving test administered by an officer charged with the administration of driving tests.

The bus shall be checked for safety and compliance with motor vehicle laws annually, and shall be in good repair and safe to operate at all times. The motor exhaust of a school bus shall be exhausted by means of a tight exhaust pipe and tail pipe so installed that none of the fumes are in or can be pulled into the bus interior. This status shall be tested with suitable testing equipment whenever there is any question of the presence of carbon monoxide fumes within the bus, and shall be done routinely not less than once per year.

The bus shall be kept clean and free from litter and dust. It shall be adequately heated and ventilated for comfort in winter months, shall be free from vermin at all times, and the number of children that may be allowed to ride in a school bus shall be determined by an officer having jurisdiction over public transportation, and the bus driver shall not permit that capacity to be exceeded at any time.

Chapter XXIX

Temporary Measures of Sanitary Control

Outdoor life in the United States plays no small part in the course of our lives. Millions go camping every year, scores of lumber and mining camps spot the country, trappers and project builders spend month after month in camps, boy scouts and horticultural workers and not least the vacationists live in the outdoors for a great part of the warm season. Very important and not to be forgotten by the sanitarian are the temporary and emergency requirements in living occasioned by catastrophies, such as floods, fires, storms, military emergencies, and forced economic migrations which require the strictest discipline in maintaining livable conditions in accordance with sanitary science.

From a knowledge of sanitation of normal or permanent living conditions as exist in town and country, the sanitarian should be able to improvise sanitary facilities for such situations that require temporary application of sanitary science. In this chapter will be grouped together the more important techniques for maintaining sanitary control over temporary situations. The greatest contributor to this phase of sanitation is the army sanitary corps, which, from the necessity of maintaining health for troops on the move has created an excellent sanitary technique for temporary control measures. Permanent camps should have sanitary facilities which are no different than those required for the ordinary environmental sanitation.

Housing

Temporary housing may consist of various types of units, from abandoned living quarter structures, warehouses, barns and factories to canvas tentage. Among the most important housing factors to be dealt with are crowding and ventilation. The fundamentals of living space and ventilation will be found discussed elsewhere in this book. Here it is pertinent to give a few practical suggestions.

The following rules should be followed as close as the particular situation will allow:

1) 60 square feet should be allowed for each bed or cot; 50 square feet in emergency.
2) 720 cubic feet of air space for each individual; 500 cubic feet in emergency.
3) Double decker beds or cots mean that the floor space be doubled for each bed.
4) In an infirmary, 100 square feet or more is allowed in case contagious cases are present.
5) Consideration must be given to space taken up by equipment and house furnishings in calculating air space.
6) The distance between the heads of sleeping individuals should be no less than 6 feet, therefore in small quarters, rows of beds or cots should be placed alternately in head to foot relation. This will increase the distance between the heads of sleeping persons. A diagrammatic illustration of such staggering of beds is shown on Fig. 1.
7) 1 to 1.5 square feet of inlet and outlet space for ventilation is required for each 10 persons when outside temperature is about 50° F.
8) Where a room has windows on one side only, the outlets may consist of roof ventilators.
9) In cold weather adequate ventilation may be obtained by opening the windows at the top and allowing cracks in door and floors to serve as inlets.
10) Because tents have a great disadvantage in heating and ventilating during cold weather, better control might be afforded if a wooden floor and frame were provided for the tent, including a wooden door. The army standard pyramidal tent is 16' x 16' having an area of about 250 square feet. The walls are 6'4" high and the peak of the roof in the center is 15'6" high. This normally houses 6 people. The peak should be kept open and provisions made for admitting air around the bottom of the tent. The interior should be thoroughly aired daily. The sides of pyramidal tents should be furled and front and rear of wall and shelter tents opened widely. All tents that do not have floors should be struck at least once each week and the sites exposed to air and if weather conditions permit, to sunshine. Pyramidal or wall tents are heated by stoves (small coal or wood sheet iron stoves.) Bedding should be aired and sunned twice weekly. Bed spacing in pyramidal tent is shown in Fig. 2.

11) Where a number of strangers are herded together in tents or barracks, for example, during flood or fire catastrophe, or in improvised sick rooms, the spread of disease, especially respiratory, can be lowered by the cubicalization of beds. The cubicle screen, of whatever material it may be made, is so installed that it will prevent the passage of exhaled droplets from the occupant of one bed to the occupant of another. A cubicle screen should extend to not less than 2 feet nor more than 4 feet above the surface of the bed at the head of the bed. The height above the bed may be decreased toward the foot of the bed. If cubicle screens be too low or too short, vertical currents of the warm exhaled air may carry infected droplets over the upper edge or around the ends to adjoining beds. If they be too high there will be undue interference with air circulation. The screen should, in all instances, extend below the surface of the bed. The methods of cubicalization are shown in Fig. 3.

Water Sterilization

Permanent water supply sanitation has already been discussed in previous chapters. Emergency or temporary supply of water is a subject that is important for a sanitarian to master if his usefulness be extended to those phases of activities that are concomitant with abnormal circumstances. Such circumstances require a quick and safe supply of water. This can be obtained in two ways, namely: by mobile filter and chlorinating units, and by quick sterilization of otherwise untreated waters. The first method has been well developed by the Army and the principles involved are very similar to those employed in any municipal water supply plant. The second method is simple and requires no technical skill beyond knowing how to do an orthotolidin test. It is, of course, important that in any case, the sanitarian must make a survey of the source and character of the supply to be used. Such a survey is no different than the inspection made of any raw water supply under normal circumstances. A detailed description of emergency chlorination is given in chapter on Public Water Supply.

The sanitarian should keep in mind during emergencies that:

1. He make use of already established water supplies if available and safe.
2. When the above are not available, ground water is safer than surface sources.
3. In choosing surface sources, he chooses a place well above sewer discharges (being alert to possible counter currents, drainage from refuse piles, dumps, oily and chemical wastes, and freshly tarred or oiled roads).
4. Clear water is easier to disinfect that turbid water.
5. Improvised toilets should be located so as not to contaminate the drinking water source.
6. Fire departments, water purification plants, or sanitation agencies may have water pumping equipment available if needed.
7. Water sprinkler trucks and glass lined milk tank trucks may be pressed into service for hauling water.
8. Oil drums, other large containers, and concrete swimming pools may be used for water storage.
9. It is safer to disinfect water in smaller containers than large storage containers.
10. If chemical disinfectants be not available, boiling is safe.
11. Water which has been boiled should be chemically disinfected when handled where recontamination is possible.
12. About 2 gallons of water are required for each person per day.

The best method available for producing a safe water supply quickly is by sterilization with a high test chlorine compound. Either HTH or chlorinated lime can be used. Because of their greater stability and solubility, HTH, perchloron, or like products are much more suitable than chlorinated lime. One gram of chlorinated lime containing 35% available chlorine, or 1/2 gram of HTH, or similar compound containing 70% available chlorine will yield approximately 2.5 ppm. of free chlorine when added to 36 gallons of water. However, if the water be more or less turbid and the chlorinated lime contains less than 35% of available chlorine, as may be the case, the residual chlorine in the treated water varies from 0.5 to 2 ppm. This quantity of chlorine will frequently produce a marked taste, and in the presence of organic matter it may cause a decidedly objectionable taste.

The Army uses a canvas bag lined with rubber and having a 36 gallon capacity for sterilizing

water. This is called a lyster bag. Other containers such as galvanized iron cans, pails, barrels, or jugs can be used. It is, of course, important that whatever container is used, it should be as devoid of organic material as possible in order not to reduce the effectiveness of the chlorine. In order to insure that the water be rendered safe despite adverse factors, the methods used should be designed to over-chlorinate within the limits of potability and to lengthen the contact time. Below will be described the recommended procedure for the Army, using the 36 gallon lyster bag. The quantities used in this procedure can be modified in accordance with the size container available:

1) Fill the bag to the 36 gallon mark which is 4 inches from the top.

2) Draw a small quantity of water through one of the faucets into a cup.

3) Put 1/2 gram of calcium hypochlorite (HTH or similar compound) or 1 gram chlorinated lime into the water in the cup, and with a clean stick rub it into a thin paste containing no visible lumps. Then add sufficient water to fill the cup 2/3 full.

4) Empty the solution of calcium hypochlorite from the cup into the water in the bag and stir thoroughly with a clean stick which is long enough to reach the bottom of the bag. Then flush out each of the faucets.

5) After the calcium hypochlorite has been in contact with the water in the bag for at least ten minutes, wash out one of the faucets by allowing a small amount of water to run through it onto the ground. Then fill a clean cup about 2/3 full of water from the same faucet.

6) Do the orthotolidin test as described in Chapter on Public Water Supply.

7) If no residual chlorine be present at the end of the ten minutes contact period, the chlorination procedure, as outlined above is repeated. Where it is suspected that the calcium hypochlorite is inert, a preliminary test with orthotolidin should be made immediately after the addition of the calcium hypochlorite solution to determine if the water contains any free chlorine at that time.

8) As a factor of safety, the water should be allowed to stand for 20 minutes after the end of the contact period, or for 30 minutes after the addition of the calcium hypochlorite before being used for drinking purposes.

The amount of hypochlorite added should vary inversely to the amount of turbidity. If the turbidity be high, then use the entire 1/2 gram. If the turbidity be low, as little as 1/3 to 1/4 of the above amount of hypochlorite may be used. If insufficient hypochlorite be used, then add more. Adding too much at first may cause the taste of water to become too disagreeable for drinking.

Sodium hypochlorite (laundry bleach) may be used as a disinfectant at the rate of 10 drops per gallon, or 3/4 ounce per 36 gallons. Iodine may be employed as a disinfectant instead of chlorine; 10 cc. of tincture of iodine can be used to disinfect 36 gallons of water. Two or three drops can be used to disinfect a canteen of water. The iodine as well as other disinfectants should be in contact with the water for at least 30 minutes before being used.

Aeration of the water by pouring it through the air from one receptacle to another will eliminate the flat taste due to boiling. If the water be very turbid, a few hours of standing may allow enough of the larger suspended particles to settle out.

Disposal of Human Wastes

Under the conditions which usually prevail in temporary camps, it becomes necessary to dispose of feces and urine directly into the earth, either in pit or trench latrines or by burial subsequent to collection in pail latrines. Under exceptional circumstances when recourse can be had to no other method, the feces may be disposed of by incineration. The same fundamentals of sanitation which apply to permanent methods of disposal of human wastes, apply here. The nitrifying bacteria normally in the soil are usually not present at depths of more than 18 to 24 inches below the surface and are not depended upon in these methods of disposal for stabilizing the organic material. In pit latrines, and usually in trench latrines, the excreta is buried below this limit so that only the intestinal bacteria are depended upon to accomplish the decomposition and stabilization. The whole process of disintegration and decomposition into stable compounds requires several months to a year or more for completion.

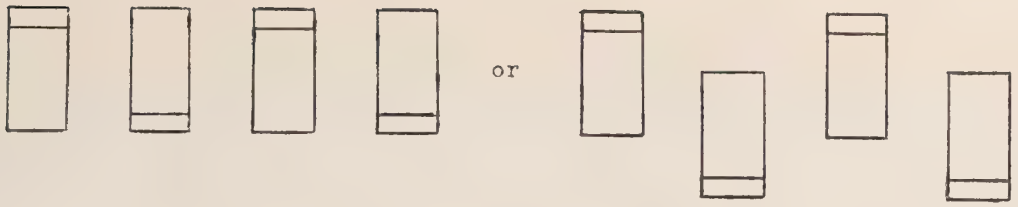


Fig. 1. Head to Foot Staggering of Beds.

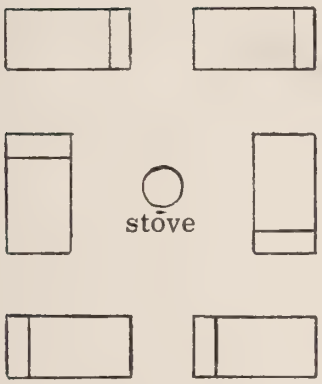
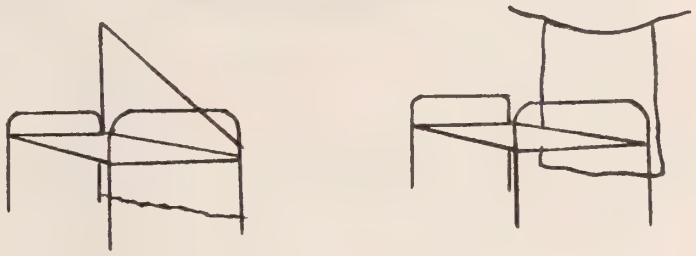


Fig. 2. Bed Spacing in Pyramidal Tent



Screen attached to bed Screen suspended on wire

Fig. 3. Cubicalization of Beds

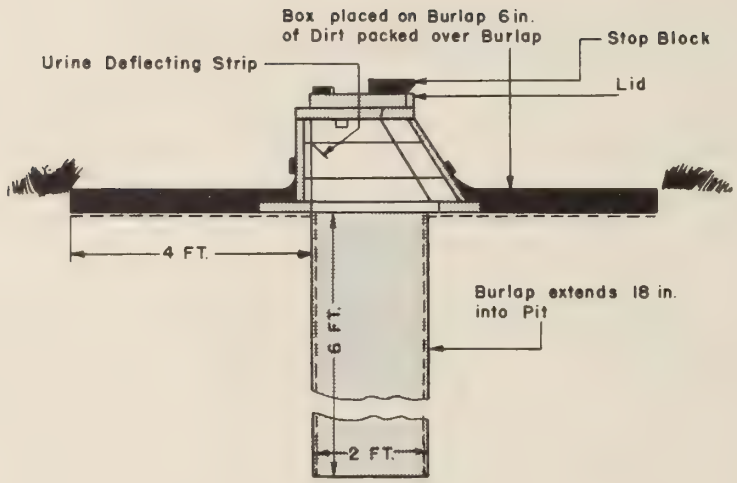
Latrine. The number of latrine seats provided should accommodate from 5 to 10% of the persons concerned, usually about 8%. Two lineal feet per seat is allowed. Usually about 8 seats, or 16 lineal feet are satisfactory for 100 persons. Trench latrines are provided for periods not to exceed 3 days duration. Pit latrines are employed where the individuals will remain in camp for periods of longer than 1 week. Pail latrines may be used in semi-permanent camps where the character of the soil or lack of space prohibits the use of pit latrines, or where the individuals are incapacitated from using an outdoor latrine.

Pit Latrine. This is an adaptation of the pit privy, but usually the latrine is not provided with a permanent wooden housing; instead, canvas is used to provide privacy. This latrine is usually 2 feet in width. The depth varies from six to eight feet, depending upon the level of the ground water table, the character of the soil, the presence or absence of a rock stratum, and the length of time that the latrine is to be used. When the water table is within a few feet of the surface, the pit should be shallow and above it. Where a clay stratum lies 4 or more feet below the surface, the pit should be shallow so that the liquid may drain out through the porous upper soil. If the clay extends to nearly the surface, then the pit can be employed more as a tank to store the excreta without much elimination of liquids by drainage.

A pit 4 feet deep should suffice for at least 2 weeks For longer periods an additional foot in depth is added for each week. Thus for a six week period, the depth should be 8 feet. All of the dirt removed in excavating the pit should be placed at least 6 feet in the rear of the pit. A drainage ditch not less than 6 inches deep should be dug around the pit in such a way as to carry surface water away from the pit. If a latrine screen or other form of enclosure be used, the drainage ditch should be on the outside of the enclosure

The typical pit latrine consists of the pit, latrine box, urinal and enclosure. (Fig. 4)

House flies lay their eggs on fecal material and the mature larvae seek a dry place in which to pupate. Because such larvae can penetrate through loose earth as far as four feet in seeking a dry place, and the freshly emerged adult is capable of penetrating loose earth for a distance of one foot or more in seeking the open spaces, it becomes necessary to prevent these insects from escaping if flies be kept at a minimum. Thus, lids are provided for the latrine box, and when the



Schematic Diagram of Deep Pit Latrine

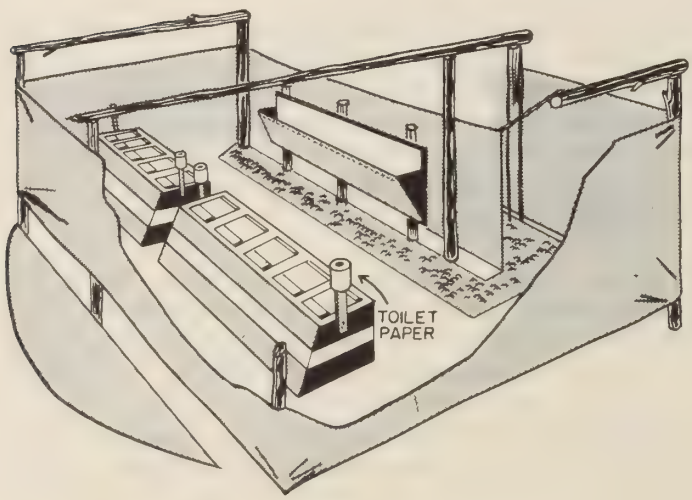


Fig. 4. Deep Pit Latrines for 100 Men, with Latrine Screen

pit is dug in loose earth such as light loam or sand and loam, the area around the pit must be fly proofed. This is done by excavating the ground around the pit for a distance of four feet. The depth of the excavation is 6 inches. The floor of the excavation is covered with burlap soaked in crude oil, the burlap being placed so that it hangs down into the pit to a depth of 18 inches. The earth is then replaced over the burlap and tamped down. In the event that burlap be not obtainable, the earth removed from the excavated area should be mixed with crude oil and tamped back into place, or if crude oil be not available, the earth may be hardened by moistening and tamping. Daily spraying with residual DDT solution will aid preventing flies from breeding. (See chapter on Insect Control).

Another measure to prevent fly breeding is to spray the inside of the box every day with an oil mixture. The following mixture is recommended: 2 parts cresol; 20 parts kerosene; 78 parts fuel oil.

The outside of the box and seats should be scrubbed daily, and washed semi-weekly with a 2% cresol solution.

The top of the box is two feet wide and the base is 2 1/2 feet wide. Thus it can be placed over a 2 foot wide pit so there is an overlapping of 3 inches on each side. Earth should be tamped around the base to prevent entrance or exit of flies. If the earth be too loose it may be necessary to support the sides of the pit by a wooden frame or sand bags.

Another method of fly control is to burn out the pit from time to time, usually at intervals of several days. This is done by placing inflammable rubbish or brush on the bottom of a clean pit. The feces collect on top of it. Then with the aid of oil, the fire is produced. When the pit is filled to within 2 feet of the surface, the contents is well sprayed with crude oil or DDT and filled with earth and domed to a height of 18 inches. The spot should be marked so that the same spot is not chosen again. The latrine may be surrounded by a canvas screen, or placed in a wall tent. Proper toilet paper should be used when possible. Large tin cans make very good protection for rolls of paper in rainy weather. Materials should be provided for hand washing or hand dipping. Wash cans containing soapy water or dip cans containing a heavy solution of bleach (4 oz. to the gallon) will serve the purpose.

Bored-hole latrine. This consists of a round hole in the ground from 15 to 20 feet or more deep and 14 to 18 inches in diameter. The feces disintegrates by septic decomposition and flies do not breed in it because it is too deep. The odor is also diminished. Deep latrines may be dangerous if the soil and underground strata allows the contamination of water supplies. This type of latrine is mentioned to warn against its use.

Urinal Trough. (Fig. 4) This is constructed of wood, galvanized iron, or tin. If made of wood, it is lined with tar paper to prevent leakage. The trough is usually built to drain into a latrine pit. If the latrine be in ground with poor absorbing qualities, the urine is made to drain into a soakage pit. The interior of the trough may be sprayed with crude oil to prevent odors.

Soakage Pit Urinal. This consists primarily of a pit 4 feet square and 4 feet deep which is filled with gravel from 1 to 4 inches in diameter. (Fig. 5) The large stones are placed on the bottom and the smaller stones on top. If gravel or stones be not available, flattened tin cans, broken bottles, broken brick or pieces of concrete may be substituted. The pit is ventilated to keep down odors. Two ventilation shafts are placed on two opposite sides of the pit. They are made of 4 or 6 inch boards, and placed at a depth of about 6 inches from bottom of pit. The top opening is screened. Tile may be used instead of wooden ventilators. The shafts extend about 1 foot above the surface.

The pipe urinals may be made of 1 1/2 to 2 inch cast iron or galvanized iron pipes. One pipe is placed in each corner of the pit at an angle of 30 degrees from the vertical plane. It extends 1 foot into the pit and 2 feet above the pit. A metal or tar paper funnel is placed in each pipe to receive the urine. One such pit can serve 100 men. The funnels should be replaced at intervals to prevent odors. Use no oil spray here. To abandon pit, just remove pipes and ventilating shafts.

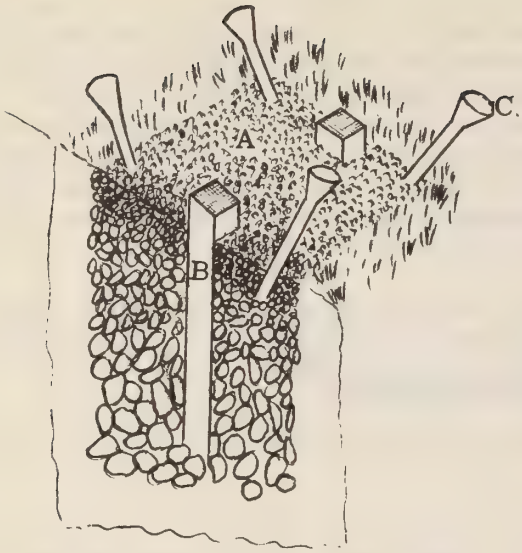


Fig. 5. Urine Soakage Pit

A - Graded Rock Bed Filling Pit

B - Ventilator Shafts

C - Pipe Urinals

Straddle or Trench Latrines. These are used when other methods are impractical, i.e., to be used 3 days or less, or when materials for other types are not available. Such a trench is one foot wide and 2 feet deep. A length of 8 feet will take care of 50 persons. The excavated dirt is placed at both ends of the trench. A shovel or paddle is provided so that each evacuation may be covered with earth. Feces and urine both are evacuated into this trench. When the trench is filled to within 1 foot of the surface, the pit is completely filled with the remaining earth. A mound of earth about 18 inches high is formed over the filled pit in order to allow for the settling of the earth. It might be well to spray the contents of the pit with the above described cresol, kerosene, oil mixture before filling in. No seats are provided for this type of latrine.

The sanitary considerations, such as location, are the same as for the pit privy which has already been discussed in detail in Chapter on Individual Excreta and Sewage Disposal Systems.

The pail latrine is usually installed for use in buildings. The fundamentals of its construction are the same as for the pail privy. Pails are removed once daily. When a pail is removed it is immediately replaced by a clean one. The bottom of the clean pail should be covered to a depth of about 1 inch with a 2% cresol solution or crude oil to serve as a deodorant. The contents of pails are disposed of by burial, by emptying into a manhole, by incineration, or by placing into a septic tank.

Disposal of Kitchen Wastes

Kitchen wastes may be classified into three categories: 1) Garbage, 2) Liquid Wastes, 3) Bath and Wash Water.

Temporary measures for garbage disposal are mainly: 1) Burial, 2) Open Incineration.

Burial. In camps of less than one week duration which serve a large personnel, garbage can be adequately disposed of by burial. If the camp be made up of only a few persons, burial is adequate for an extended period of time. Usually a pit of suitable size is dug near the camp or kitchen, and when filled with garbage to within about one foot of the surface, the pit is sprayed with oil and burned, then spread with crude oil, covered with earth, and firmly tamped down. A garbage pit should not be within 100 feet of any source of water used for drinking or cooking and should be on the down hill side.

Plowing under thin layers of garbage results in temporary periods of fly breeding nuisances.

Open Incinerators. For prolonged temporary disposal of garbage, or for a camping period of

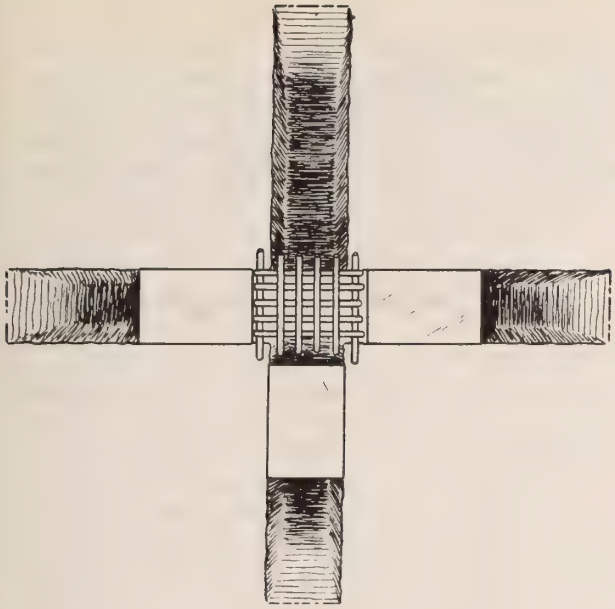


Fig. 6. Cross Fire Trench

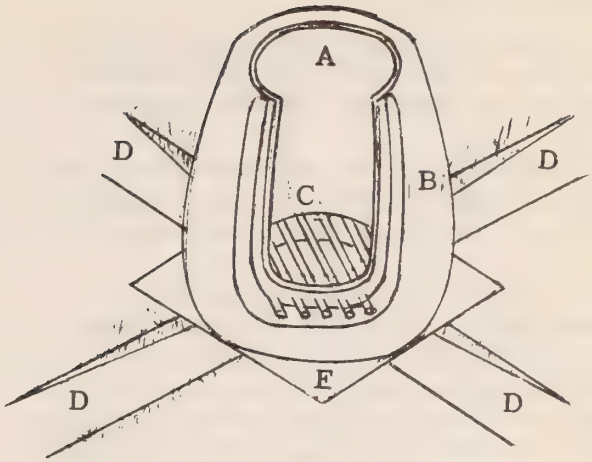


Fig. 7. Barrel and Trench Incinerator
(See legend)

longer than a week for large groups of persons, open incineration is the method of choice. Such an incinerator has no stack and therefore no draft other than that produced by the wind and heat. The gases are not decomposed and there is inadequate or no pre-heating and drying of the garbage. Consequently it creates nuisances due to obnoxious odors.

Basically, the open incinerator is a pit in which the garbage is burned by being placed directly on a fire or on a grate immediately above the fire. Variations in the construction of the different types are made with a view of improving the draft or providing facilities for drying the garbage. Owing to the great loss of heat in open incinerators and the low fuel value of the garbage, fuel such as wood and combustible rubbish must be used to dry and burn the garbage. The garbage must be incinerated in small amounts since the fire is easily smothered by fresh or wet garbage. Garbage must therefore be as dry as possible. No light material such as paper should be allowed to blow away from the fire. Tin cans, bones, and the like should be burned in order to destroy as much as possible of the organic matter in them, then they are removed from the incinerator and disposed of by dumping or burial. If mosquitoes be present in the vicinity, those tin cans which are not buried should be flattened with a hammer. Incinerators should be located as far as practical from camp, preferably 500 yards or more.

The principle types of open incinerators are the: 1) Barrel and trench incinerator (Cross Fire Trench); 2) Rock pit incinerator; 3) Multiple shelf incinerator; 4) Drying pan incinerator.

Each type is susceptible of many modifications and the illustrations given in Figs. 6, 7, 8, 9 and 10 present only the fundamentals involved in construction and operation.

For the Cross Fire Trench (Fig. 6) two trenches are dug, 8 feet long, 1 foot wide, one foot deep, crossing at the centers, and with each end of the trenches tapering to ground level. A grate is made of scrap iron over the intersection of the trenches. Three pieces of sheet metal are placed over 3 of the trenches to block them off, leaving the fourth, on the side facing the direction of the wind, open to form a draft. On the grate is placed a 55 gallon drum which has both ends removed. Two of these trench incinerators will take care of about 500 persons.

The fire is started on top of the grate. If it be difficult to keep the fire going when garbage is added, reinforce it with another fire under the grate. Do not smother fire by adding too much garbage at a time.

A metal frame 2 feet above the grate may be erected to hold cooking containers.

A variation of this type is the Barrel and Trench Incinerator, Fig. 7.

In the Barrel and Trench Incinerator
A - Barrel with both ends removed and surrounded with clay (B) 6 to 12 inches thick.
C - Grate irons inserted through clay and barrel wall about 6 inches above surface of ground and about 3 to 4 inches apart.

A small fire is made in one of the trenches (D). The clay is slowly dried for several hours without burning the wooden barrel. After the clay is well baked, a brisk fire is built under the barrel and the wooden mold burned out. Such an incinerator will be serviceable for about 2 weeks. If 10% to 20% lime be added by volume to clay, the finished product will be stronger.
E - Corrugated iron sheet holds the barrel over the trench.

A similar type of incinerator may be built of brick and clay and will last much longer. A galvanized iron garbage can from which the bottom has been removed may also be used.

This is about the most efficient type of incinerator for temporary use.

Fig. 8. Rock Pit Incinerator, a U-shaped pit made or rock of clay: about 4 1/2 feet long, 2 feet wide, 18 inches deep. Walls made of stone and rubble, 6 to 12 inches thick; clay may also be used.

Floor is made of a layer of stone or tamped earth.

In order that a suitable draft may be obtained, the floor should be flush with, or slightly below the surface of the ground.

This type of incinerator is useful where the kitchen will be in operation for only a few days.

Fig. 9. Multiple Shelf Incinerator: A rectangular brick stack, 3 to 5 feet wide, 4 feet long, 8 to 12 feet high.
A - Grate bars of 2 inch iron pipes; end of grate bars are so placed as to be easily removed when warped.
B - Shelves, 4 to 6 in number, 18 to 24 in. from grate to top, made of 1/4 inch boiler plate. One inch for expansion is allowed on each of 3 sides next to wall.
C - Fire box (space between grate and lowest shelf) has a substantial iron door.

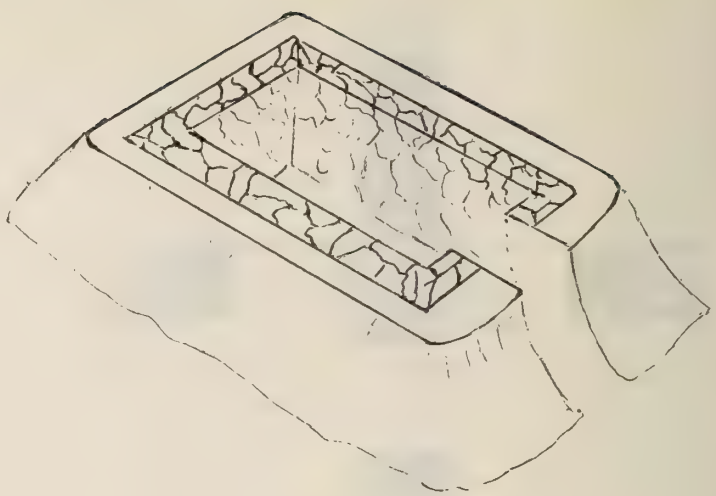


Fig. 8 Rock Pit Incinerator

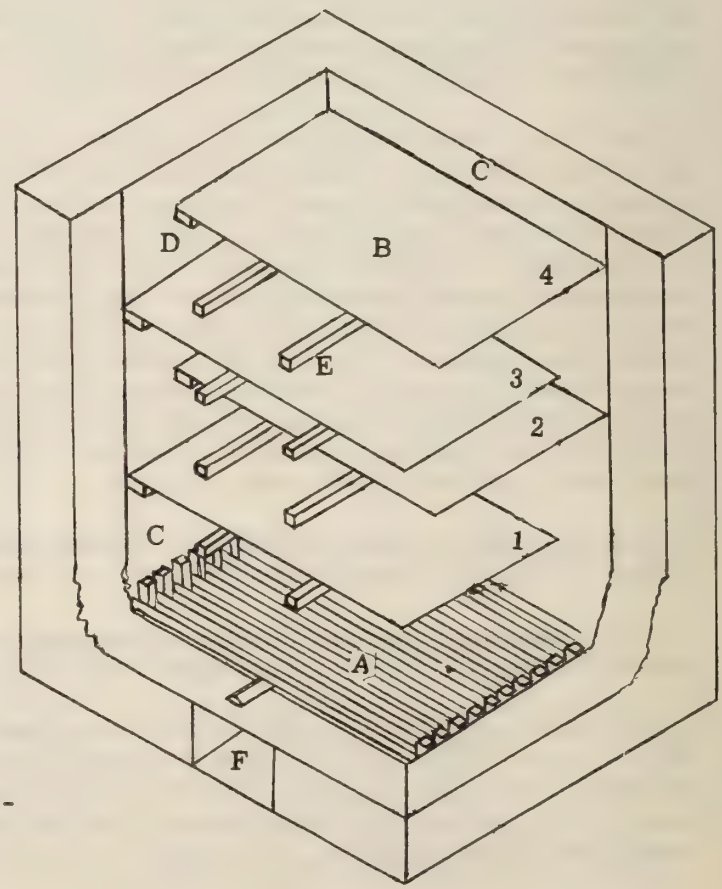


Fig. 9. Multiple Shelf Incinerator

D - Shelf supports of fire brick embedded in the walls on 3 sides of stack.
E - Pairs of iron or steel bars extending across the stack supporting shelves. Ends of bars are inserted into opening in stack walls supported by metal plates to prevent weight from breaking the brick. Outer ends of these openings are closed by loosely placed brick or concrete blocks for easy removal of bars when they get warped.
F - Outer opening to ash pit.

A slot 10 to 15 inches wide between wall and shelves on alternate sides form a zig-zag air channel from grate to top. Thus, shelves 1 and 3 have slot opposite to those of shelves 2 and 4. Just above each shelf on side where it approximates the wall, two stoke holes are placed, each equipped with iron door. As garbage on lower shelf dries, it is pushed into fire with rake through stoke holes, and garbage from each shelf above is pushed down to next lower shelf by rake through stoke holes.

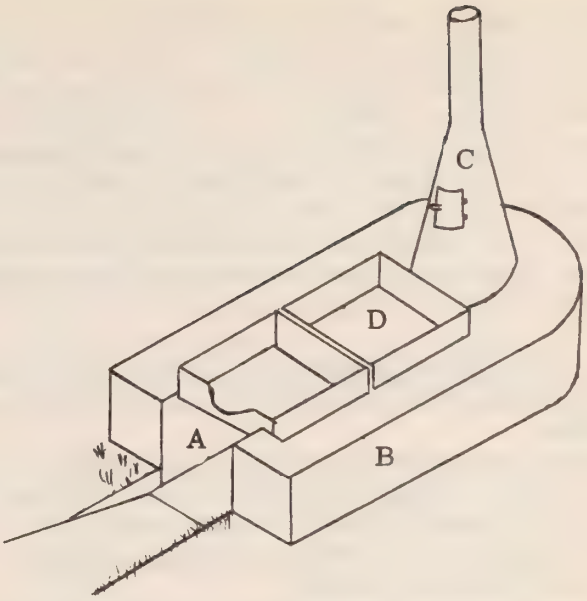


Fig. 10. The Drying Pan Incinerator

Fire must not get too hot lest warping develops. When metal begins to show faint tinge of red, the draft is reduced by manipulating the doors.

The garbage is slowly dried and partially cooked so that malodorous gases are produced due to low temperature which must be maintained. Since this type of incinerator is like a stack and is no higher than 8 to 12 feet, the smoke produced is practically on the ground level and may produce a nuisance. It requires much less fuel when properly operated than any type of open incinerator. When properly constructed, wind and rain interfere but little with its operation.

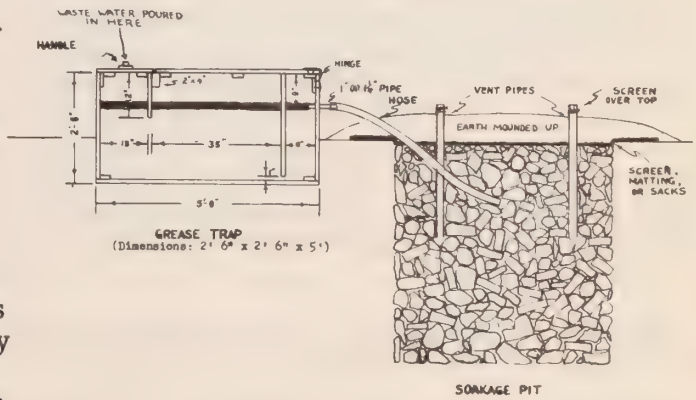


Fig. 11. Grease Trap and Soakage Pit

The Drying Pan Incinerator, Fig. 10, consists of pit 6 ft. long, 18 inches wide, 18 inches deep (inside measurements), the bottom of which serves as the firebox - A.
B - Walls are made of brick or concrete, 10 to 12 inches thick.
C - Stack consists of a Sibley stove, or made of sheet iron with a flaring base.
D - Pans are 22 inches square, 6 to 8 inches deep.

The garbage is dried in the pans and then empties into the pit.

This type is useful where liquid wastes cannot be disposed of except by evaporation. It is not as efficient otherwise as either the barrel and trench type or rock pit type.

Disposal of Liquid Kitchen Wastes

The important factors concerned here are:

1) Separating grease from the rest of the liquid waste.
2) Disposing of the non-greasy liquid waste so that no hazard or nuisance is created.

All the kitchen wastes are first passed through a grease trap of one type or another.

Types of easily made grease traps:

1) The Filter Grease Trap: This may consist of a galvanized iron pail, large can, or barrel with holes punched in bottom. This container is then placed in center of soakage pit with its bottom about 2 inches in the ground. The container is then filled 2/3 full with a filtering material composed of hay, grass, straw, or cloth which catches and retains a part of the grease and debris, such as bread crumbs, or vegetable fragments. A layer of gravel or broken stone or brick may be placed on bottom of container upon which layer another layer of ashes, charcoal, or fine coal is placed. The top may be covered with burlap to strain out larger pieces of debris. The burlap should be removed daily and cleaned or disposed of. The filtering material in the container should be removed twice a week and burned or buried.

2) The Baffle Grease Trap, Fig. 12, consists of:

A - Influent chamber into which the greasy fluid is emptied.

B - Baffle; lower edge is separated from bottom by a space (E) of about one inch which allows the water on both sides of baffle to reach same level but prevents the grease which flows on top from getting into effluent chamber.

C - Effluent chamber which contains the liquid separated from the grease.

D - Outlet of effluent chamber from which liquid flows onto soakage pit.

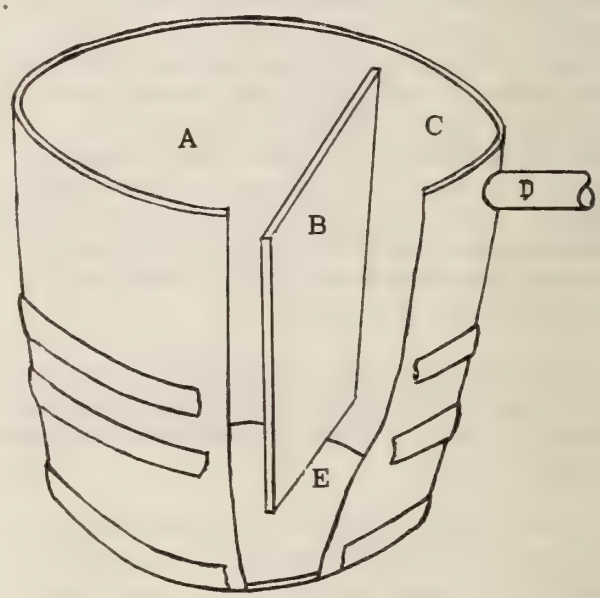


Fig. 12. Baffle Grease Trap made of Half Barrel

The Baffle Grease Trap stands on the edge of the soakage pit. The coarse, solid debris is removed from the fluid before it enters the influent chamber of the trap by means of a strainer made of burlap, or by any other method. The layer of grease which accumulates on the water surface in the influent chamber is skimmed off daily. The trap should be emptied and thoroughly cleansed about once a week. The sediment removed should be burned or buried.

Soakage Pit and Trench. The construction of the soakage pit is the same as for urine disposal (Fig. 5), and is illustrated in Fig. 11.

Where the ground water table of clay or rocky stratum lies too close to the surface to construct a soakage pit, a soakage trench may be substituted. A soakage trench consists of a central pit, 2 feet square and 1 foot deep, from each corner of which radiates a trench outward for a distance of 6 feet. The trenches are 1 foot deep where they leave the central pit and slope to a depth of 18 in. at the other peripheral extremity. They are about 1 foot wide. The central pit and trenches are filled to the surface with stone, broken brick or concrete, flattened tin cans, broken bottles or any other such material. Broken stone, 1/2 to 3 inches in diameter, should be used for contact material if obtainable. Soakage pits are built close to the kitchen. The fundamentals upon which a soakage pit operates are the same as that of the contact bed in purification of sewage which is described in chapter on Sewage Control.

Disposal of Bath and Wash Water. Disposal of these liquids are accomplished as described above by soakage pits or trenches which are larger than those used for kitchen liquid waste. A grease trap should be installed to remove the soap from the water before it reaches the contact bed.

In the absence of soakage pits or trenches, bath water may be disposed of for a short time in open trenches. These pits or trenches should be at least 100 ft. long and on the downgrade side from sources of water used for drinking.

Food Sanitation

The fundamentals for handling and storage of food are the same for temporary camps as for restaurants, except that the facilities would be less costly and less elaborate. Technique rather than facilities must be stressed in this case, for after all, it is the knowledge of principles applied technically in handling food which will prevent food poisoning or other disease transmission by food.

There are five general techniques which when applied will reduce the possibility of food poisoning. These are refrigeration, sanitation, personal hygiene, cooking and processing, and insect and rodent control.

For the prevention of food poisoning in disaster feeding, the following points should be remembered (see chapter on Food and Drug Control.)

1. Quick cooling and refrigeration of perishable food stuffs at 50° F. or below.
2. Temperature below 50° F. may be attained in cellars, underground storage areas, watertight cans suspended in running water such as streams, wrapping pots with tight fitting lids in wet blankets.
3. Careful screening of food handling personnel to eliminate carriers of disease or those who have discernable signs, such as pimples, boils, skin eruptions, lacerations, diarrhea, colds, and the like.
4. Eliminate foodstuffs which commonly are sources of food poisoning, such as creamed dishes, hash, puddings, poultry salads, etc.
5. Proper, quick, and thorough cooking of all foods.
6. Foods should be allowed to remain as short a period as possible between the temperatures of 50° F. to 110° F.
7. Raw milk should never be used. Pasteurized milk found in clean bottled or packaged containers may be used only when passed by medical authority. Canned and powdered milk are safe if handled carefully. Once a can is opened or dry milk is reconstituted, it becomes equally suspect as other milk. If used within 3 hours and stored carefully prior to usage, there is little danger. If 3 hours have elapsed, the milk should be scalded before using. If the container be exposed in the presence of people while serving, the milk should not be used.
8. Safe water must be used to rehydrate dehydrated foods.
9. The cans of canned food should be inspected for spoilage before opening.
10. Guard against chemical poisoning of food stuffs.
11. Menus should be simple, and foods requiring a great deal of handling should be avoided. Those requiring the minimum handling are soups, canned meats and beans, canned vegetables, dehydrated potatoes, canned juices, powdered or canned milk, canned fruits, packaged cookies, crackers, and biscuits.
12. Avoid over preparation of foods and leftovers. Leftovers should be used within 24 hours or sooner.
13. Food should be prepared as close as possible to time of serving. If serving be delayed, keep food hot and covered.
14. Guard food against insects and rodents.
15. Stored foods should have good air circulation to prevent moisture accumulation, and should be lightly covered to allow heat to escape.
16. Utensils and equipment should be cleaned and sterilized. Wood surfaces should be scraped and treated with a disinfectant. Utensils should be air dried.
17. The feeding of raw food should be discouraged.
18. Any food mixed with mayonnaise should be discarded if leftover.
19. If radioactive dust be suspected of fowling food or water, competent monitoring should be brought in (see chapter on Radiation Hazards).

Sanitary Regulations for Camps: See chapter on Housing.

Chapter XXX

Occupational Hygiene

Occupational hygiene brings the sanitarian into close relationship with many professional workers besides the physician and sanitary engineer. The problems of industrial hygiene involve, in a special way, the chemist, the physicist, the industrial engineer, the personnel administrator in industry, the labor union official and management of industry, the sociologist and others. Among all these specialists, the sanitarian is the general practitioner. The specialists make the diagnoses of the special industrial hazards, they also make their recommendations for controlling these special conditions. The sanitarian carries through to see that the special recommendations are adhered to and that the general sanitary conditions are brought up to and maintained at an optimum level. A good sanitarian should be able to discover the usual types of sanitary defects in a factory or workshop. He should know when illumination is adequate or inadequate, when toilet and washing facilities are sanitary, whether heating and ventilation are adequate, whether dust and fumes should be controlled and a host of other details associated with industrial environments. He should even know whether certain chemical processes are dangerous to the workman, whether cross-connections are existent and whether one or another occupational practice may lead to disease or accident. After discovering such conditions he should bring the problem to the industrial hygiene engineer for solution. But in order for him to be so useful, he should acquaint himself with the physical, chemical, and biological factors which may cause occupational hazards.

The history of occupational hygiene began as early as the time of Hippocrates as was pointed out in Chapter I, the Historical Outline of Sanitation. Official interest in this problem seems to have begun almost immediately after the establishment of our government when the life of our economic growth depended on the development of our commercial interests. Protection of our seamen became a problem of prime importance and resulted in the establishment in 1798 of the Marine Hospital Service, a medical service for seamen based originally on the idea of compulsory medical insurance. After that,the protection of the working conditions of children came to the fore, then interest in industrial safety measures, then workmen's compensation and lastly a renewed interest in the medical care of workers. The Office of Industrial Hygiene and Sanitation was established by an Act of Congress in 1914. It received real impetus during the first world war when definite measures were taken toward the conservation of workers' health in vital war industries. But development of this program was slow on the state level. Prior to 1935, only 4 states and 2 cities had established health department industrial hygiene units. In 1936, Federal funds were made available for this work and 12 units were established in that year. By the end of 1939, 31 industrial hygiene units were operating in 27 states. By the end of 1946 there were 56 units, 44 in State health departments, 7 in cities; 1 in a county and 1 in the District of Columbia, Alaska, Hawaii and Puerto Rico. Since then, very little progress has been made in the further extension of this program. In 1950, there were still 44 state health departments with industrial hygiene units, and the local units had increased to 13. Nevertheless, by this time every state government was offering in varying degrees some occupational health services. There are 10 types of official state agencies performing duties related to occupational health. In 8 states, the health department alone is responsible for this service. In 1947 there were 355 professionals working in health department programs, and in 1950 there were only 361. Not only is the health department personnel working in this program very meagre, but so are the staffs working in the State Labor Departments' industrial safety programs. In 1950 the latter employed about 800 inspectors to safeguard upward of 40, 000, 000 workers subject to state labor laws. A majority of these were operating part-time in this aspect of work.

The larger industrial organizations have expanded in their industrial hygiene activities and labor unions have also entered the field. Insurance companies have shown a similar expansion and most of them now maintain laboratories and personnel to study industrial health problems.

This recent growth of industrial hygiene resulted in part from the great demand for social security which arose from the 1929 depression and its progress was further stimulated by the second world war. A similar increased interest in the safety of workers has been accomplished by the development of workmen's compensation laws. Stimulated, belately, by European workmen's compensation legislature, the first such law enacted in the U.S. was in Maryland in 1902, but it was soon declared unconstitutional. The first such law that survived was passed in New

York State in 1908. Since then, workmens' compensation legislation has been enacted by all states. Federal laws cover government employees, longshoremen and labor workers, and private employees in the District of Columbia. Because of coverage limitations it has been estimated that less than fifty percent of the workers are protected by these laws. About one-fourth of the states fail to provide coverage for occupational diseases. Agricultural and domestic workers are usually excluded. More than one-half of the states have an elective law whereby employers may refuse to operate under the compensation act if they prefer to risk an injured worker's suit for damages. In some states the law applies only to certain "hazardous" industries and in others there are numerical limitations on required coverage. One state exempts those who have less than 15 employees and twenty states exempt those who have less than 6 employees. Most state laws cover public (state and local) employees but in some the coverage is limited or voluntary and in one (Missouri) they are specifically excluded. The gains made by the growth of occupational hygiene programs have resulted in lowered insurance rates, less absenteeism, and increased production efficiency. The savings are frequently found to more than pay the cost of a good health and safety program.

Physicians have been very slow in accepting one of the most important items in occupational hygiene programs, i. e., the reporting of occupational diseases. In most cases the only reports are those made in connection with claims for compensation. This is primarily a matter of education since many physicians do not recognize the occupational origin of diseases they treat. An intensive educational campaign is urgently needed since knowledge of the incidence of occupational diseases is the basis for planning control activities.

Although industry has been slow to accept this program, legislators have been even slower, and in those states where industrial hygiene laws do exist there has been a tendency not to push their enforcement. Progress, however slowly, marches on.

There are also certain parts of the occupational hygiene program which labor has been prone to frown upon, especially that part which deals with pre-employment physical examination. The main reason for its reluctance in accepting this part of the program is that it fears that such procedure might be used as a weapon against its members.

Occupational hygiene may broadly be defined as that aspect of public health of people while at work. The objectives of occupational hygiene are (1) to determine whether the working conditions of people are harmful to their health and to prevent such conditions from occurring, and (2) to promote the best possible physical, mental and social health of people at work. Since 30% of the labor force in the United States is female, and since sickness absenteeism is almost 3 times as great among females than males, this latter aspect of the occupational hygiene program must therefore include various phases of the maternal-child health program.

More specifically, occupational hygiene is concerned with preventing, (1) occupational diseases caused by harmful chemical substances, (2) physiological distress due to physical agents in the industrial atmosphere such as temperature, humidity and radiant energy, (3) abnormal stresses due to posture, movements, improper work methods, or discomfort, (4) deteriorating effects on degenerative diseases and on the immunity mechanism, (5) industrial infections such as Q fever, anthrax and brucellosis, (6) atmospheric pollution, (7) industrial accidents, (8) non-occupational diseases by medical examination of industrial workers It is further concerned with promoting maximum health conditions by determining (1) the optimum conditions of work, (2) the best design of machinery and processes which will reduce stress on the worker, (3) the best types of work for the individual based on ability, age, sex, etc., (4) the proper types of work for rehabilitation of the handicapped, (5) and the character of interrelations of people at work which will promote sound mental, emotional and social attitudes. Just as in any aspect of public health, research is very important to progress in industrial hygiene.

It was estimated that in 1952, 400 - 500 million man days of work were lost in industry from physical disability. Studies made in industry indicate that about 10-15% of time lost from work because of physical disability is due to industrial causes, and 85-90% due to causes which are generally common to the entire population. Thus, well over 45, 000, 000 man days of work were lost in industry due to industrial causes in 1952. This figure is not decreasing. One, then, cannot doubt the importance of the occupational hygiene program, but neither can one doubt the importance of some plan by which, about 400, 000, 000 man days of work lost due to non-occupational causes

can be reduced to minimum. Such a plan need not only be attractive to the general public as a humane public health measure, but also to industry, since recent estimates indicate that the loss to industry is about 1 1/2 times the loss of pay which the workers suffer.

Most of the progress which has been made in the field of industrial health protection has been accomplished in big industry. The programs usually include both medical treatment and sanitary preventive measures. Many of the large labor unions also have developed medical care and hospitalization programs.

The quality of the industrial hygiene program should be uniform in both large and small industrial plants, but this does not at present happen to be the case, since it is a greater financial burden on small industry to maintain the personnel and facilities for such a program than it is for large industry. It is urgent that something be done to equalize the quality of these services. Ninety percent of the industrial establishments in the United States are small, that is, they employ 100 or less workers. About one-half of these employ ten or less workers. A comparison of the health services available in large and small industrial plants can be seen from the following graph:

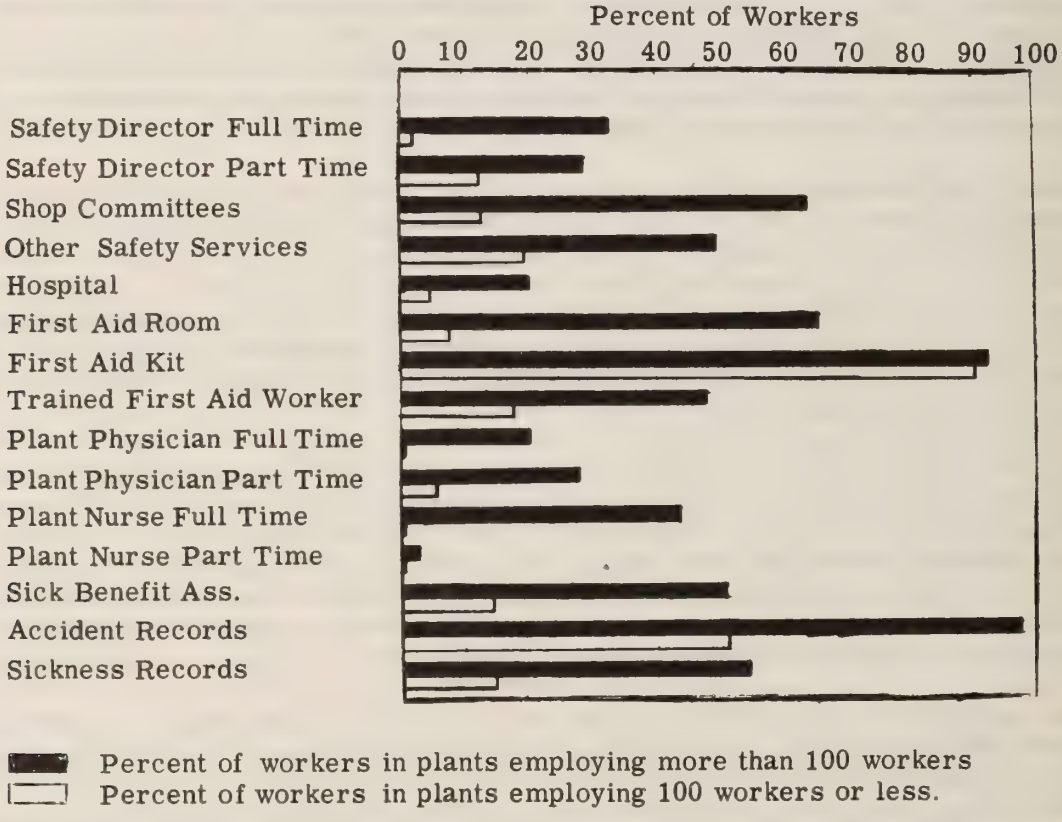

Percent of Workers
0 10 20 30 40 50 60 70 80 90 100
Safety Director Full Time
Safety Director Part Time
Shop Committees
Other Safety Services
Hospital
First Aid Room
First Aid Kit
Trained First Aid Worker
Plant Physician Full Time
Plant Physician Part Time
Plant Nurse Full Time
Plant Nurse Part Time
Sick Benefit Ass.
Accident Records
Sickness Records
Percent of workers in plants employing more than 100 workers
Percent of workers in plants employing 100 workers or less.

Fig. 1. Industrial Health Service Provisions in Plants Employing More than 100 Workers as Compared with Plants Employing 100 Workers or Less (Am. J. Public Health. Vol. 32-853-42; Buxell)

The above inequality is reflected in the fact that in 1939, the largest plants had a disabling injury frequency of eleven injuries per million man hours worked, while in the smallest plants the frequency was seventeen and one-half injuries per million hours worked. Thus the injury rate in small establishments is about 50% greater than in the large establishments.

Twelve years later, 1951, the National Safety News reported "that the accident frequency rate for small plants is 2 1/2 times as great as in large plants".*

Whatever progress is being made in solving the difficulties of providing adequate medical service for small plants, the National Health Forum of 1959 concluded that "Today, occupational health services—varying from very extensive to rudimentary—do exist in a majority of the 8,000 plants employing more than 500 workers each. But, of the three million small business establishments—

*Small Plant Health and Medical Programs, Public Health Service Publication No. 215, May 1952.

Table 1 Agents Capable of Causing Disabilities, and Their Maximum Allowable Concentration, Values Adopted by the American Conference of Governmental Industrial Hygienists
1965

	Substance	ppm*	Mg/M³**
	Acetaldehyde	200	360
	Acetic Acid	10	25
	Acetic anhydride	5	20
	Acetone	1,000	2,400
	Acetonitrile	40	70
	Acetylene tetrabromide	1	14
	Acrolein	0.1	0.25
	Acrylonitrile - Skin	20	45
	Aldrin (1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a hexahydro-1,4,5,8-di-methano-napthalene) -Skin	-	0.25
	Allyl alchohol-Skin	2	5
	Allyl chloride	1	3
C	Allyl glycidyl ether (AGE)	10	45
	Allyl propy disulfide	2	12
	Ammonia	50	35
	Ammonium sulfamate (Am-mate)	-	15
	n-Amyl acetate	100	525
	Amyl Alcohol (isoamyl alco-hol)	100	360
	Aniline - Skin	5	19
	Antimony & compounds (as Sb)	-	0.5
	ANTU (alpha naphthyl thiourea)	-	0.3
	Arsenic & Compounds (as As)	-	0.5
	Arsine	0.05	0.2
	Barium (soluble compounds)	-	0.5
C	Benzene (benzol) -Skin	25	80
	Benzidine - Skin	-	A1
	Benzyl chloride	1	5
	Beryllium	-	0.002
	Boron oxide	-	15
C	Boron trifluoride	1	3
	Bromine	0.1	0.7
	Butadiene (1,3-butadiene)	1,000	2,200
	2-Butanone (methyl ethyl ketone)	200	590
	2-Butoxy ethanol (Butyl Cellosolve)-Skin	50	240
	Butyl alcohol	100	300
	tert. Butyl alcohol	100	300
C	Butylamine -Skin	5	15
C	tert. Butyl chromate (as CrO_3) Skin	-	0.1
	n-Butyl glycidyl ether(BGE)	50	270
	Butyl mercaptan	10	35
	p-tert. Butyltoluene	10	60
	Cadmium oxide fume	-	0.1
	Calcium arsenate	-	1
	Calcium oxide	-	5
	Camphor	-	2
	Carbon dioxide	5,000	9,000
	Carbon disulfide - Skin	20	60
	Carbon tetrachloride-Skin	10	
	Chlordane (1,2,4,5,6,7,8,8-octachloro-3a,4,7,7a tetrahydro-4,7-methanoin-dane)-Skin	-	0.5
	Chlorinate camphene, (toxaphene)-Skin	-	0.5
	Chlorinate diphenyl oxide	-	0.5
	Chlorine dioxide	0.1	0.3
C	Chlorine trifluoride	0.1	0.4
C	Chloroacetaldehyde	1	3
	Chlorobenzene (monochlorobenzene)	75	350
	Chlorobromomethane	200	1,050
	Chlorodiphenyl (42% chlo-rine) -Skin	-	1
	Chlorodiphenyl (54% chlo-rine) -Skin	-	0.5
C	Chloroform (trichlorome-thane)	50	240
	1-Chloro-1-nitropropane	20	100
	Chloropicrin	0.1	0.7
	Chloroprene (2-chloro-1, 3-butadiene) - Skin	25	90
	Chromic acid and chromates (as CrO_3)	-	0.1
	Cobalt	-	0.5
	Copper Fume	-	0.1
	Dusts and Mists	-	1.0
	[Crag (R) herbicide sodi-um 2-(2,4- dichlorophe-noxy) ethanol hydrogen sulfate]	-	15
	Cresol (all isomers)-Skin	5	22
	Cyanide (as CN) - Skin	-	5
	Cyclohexanol	50	200
	Cychlohexanone	50	200
	2,4-D (2,4-dichlorophe-noxy-acetic acid)	-	10
	DDT [2,2-bis (p-chloro-phenyl)-1,1,1-trichloro-ethane] - Skin	-	1

*Parts of vapor or gas per million parts of air by volume at 25°C and 760 mm. Hg pressure.
**Approximate milligrams of particulate per cubic meter of air.
A Numbers indicate high toxicity and should be kept at lowest possible levels.
C Ceiling value that should not be exceeded.

Table I (Continued)

	Substance	ppm*	Mg/M^3**
	DDVP (O, O-Dimethyl-2,2-dichlorovinyl phosphate)-Skin	-	1
	Decaborane - Skin	0.05	0.3
	Demeton (systox) (R) - Skin	1.0	-
	Diacetone alcohol (4-hydroxy-4-methyl-2 pentanone)	50	240
	Diborane	0.1	0.1
C	o-Dichlorobenzene	50	300
	p-Dichlorobenzene	75	450
	Dichlorodifluoromethane	1,000	4,950
	1,1-Dichloroethane	100	400
	1,2-Dichloroethane (ethylene dichloride)	50	200
	1,2-Dichloroethylene	200	790
C	Dichloroethyl ether-Skin	15	90
	Dichloromonofluoromethane	1,000	4,200
C	1,1-Dichloro-1 nitroethane	10	60
	Dichlorotetrafluorethane	1,000	7,000
	Dieldrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a octahydro-1,4,5,8-dimethano-naphthalene)- Skin	-	0.25
	Diethylamine	25	75
	Difluorodibromomethane	100	860
C	Diglycidyl ether (DGE)	0.5	2.8
	Diisobutyl ketone	50	290
	Dimethyl acetamide - Skin	10	35
	Dimethylaniline (N-dimethyl-aniline)- Skin	5	25
	1,1-Dimethylhydrazine - Skin	0.5	1
	Dimethylsulfate - Skin	1	5
	Dinitrobenzene (all isomers) - Skin	-	1
	Dinitro-o-cresol - Skin	-	0.2
	Dinitrotoluene - Skin	-	1.5
	Dioxane (diethylene dioxide) - Skin	100	360
	Dipropylene glycol methyl ether - Skin	100	600
	Endrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro 1,4-endo-5,8-dimethanonaphthalene)-Skin	-	0.1
	Epichlorhyrin-Skin	5	19
	EPN (O-ethyl O-p-nitrophenyl thionobenzenephosphonate)-Skin	-	0.5
	Ethanolamine	3	6
	Ethyl acetate	400	1,400
	Ethyl acrylate - Skin	25	100
	Ethyl alcohol (ethanol)	1,000	1,900
	Ethyl bromide	200	890
	Ethyl chloride	1,000	2,600
	Ethyl ether	400	1,200
	Ethyl formate	100	300
	Ethyl silicate	100	850
	Ethylene Chlorohydrin-Skin	5	16
	Ethylenediamine	10	25
C	Ethylene glycol dinitrate-Skin	0.2	1.2
	Ethylene oxide	50	90
	2-Ethoxyethanol - Skin	200	740
	2-Ethoxyethylacetate (Cellosolve acetate)-Skin	100	540
	Ferbam (ferric dimethyl dithiocarbamate)	-	15
	Ferrovanadium dust	-	1
	Fluoride (as F)	-	2.5
	Fluorine	0.1	0.2
	Fluorotrichloromethane	1,000	5,600
C	Formaldehyde	5	6
	Furfural - Skin	5	20
	Furfuryl alcohol	50	200
	Gasoline	500	2,000
	Glycidol (2,3-Epoxy-1-propanol)	50	150
	Hafnium	-	0.5
	Heptachlor (1,4,5,6,7,8,8a-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindane) - Skin	-	0.5
	Heptane (n-heptane)	500	2,000
	Hexane (n-hexane)	500	1,800
	Hexanone (methyl butyl ketone)	100	410
	sec-Hexyl acetate	50	295
	Hexone (methyl isobutyl ketone)	100	410
	Hydrazine - Skin	1	1.3
	Hydrogen bromide	3	10
C	Hydrogen chloride	5	7
	Hydrogen cyanide - Skin	10	11
	Hydrogen Fluoride	3	2
	Hydrogen peroxide, 90%	1	1.4
	Hydrogen selenide	0.05	0.2
	Hydroquinone	-	2
C	Iodine	0.1	1
	Isophorone	25	140
	Isopropylamine	5	12
	Isopropyl glycidyl ether (IGE)	50	240
	Ketene	0.5	0.9
	Lead	-	0.2
	Lead arsenate	-	0.15
	Lindane (hexachlorcyclohexane, gamma isomer) - Skin	-	0.5
	Lithium hydride	-	0.025
	Magnesium oxide fume	-	15
	Malathion (O,O-dimethyl dithiophosphate of diethyl mercaptosuccinate)-Skin	-	15

* Parts of vapor or gas per million parts of air by volume at 25°C. and 760 mm. Hg pressure.

** Approximate milligrams of particulate per cubic meter of air.

C Ceiling value that should not be exceeded.

Table 1 (Continued)

	Substance	ppm*	Mg/M3**
C	Manganese	-	5
	Mercury - Skin	-	0.1
	Mercury (organic compounds) - Skin	-	0.01
	Mesityl oxide	25	100
	Methoxychlor (2,2-di-p-methoxy-phenyl - 1,1,1-trichloroethane)	-	15
	Methyl acetate	200	610
	Methyl acetylene (propine)	1,000	1,650
	Methyl acrylate - Skin	10	35
	Methylal (dimethoxymethane)	1,000	3,100
	Methyl alcohol (methanol)	200	260
C	Methyl bromide - Skin	20	80
	Methyl cellosolve (2-methoxyethanol)-Skin	25	80
	Methyl cellosolve acetate (ethylene glycol monomethyl ether acetate) - Skin	25	120
C	Methyl chloride	100	210
	Methyl chloroform (1,1,1-trichloroethane)	350	1,900
	Methylcyclohexane	500	2,000
	Methylcyclohexanol	100	470
	o-Methylcylohexanone - Skin	100	460
	Methyl formate	100	250
	Methyl isobutyl carbinol (metyl amyl alcohol)-Skin	25	100
	Methyl methacrylate	100	410
C	α Methyl styrene	100	480
C	Methylene bis phenyl isocyanate (MDI)	0.02	0.2
	Methylene chloride (dichloromethane)	500	1,750
	Molybdenum (soluble compounds)	-	5
	(insoluble compounds)	-	15
	Monomethyl aniline - Skin	2	9
	Naphtha (coal tar)	200	800
	Naphtha (petroleum)	500	2,000
	Naphthalene	10	50
	β - Naphthylamine	-	A2
	Nickel carbonyl	0.001	0.007
	Nicotine - Skin	-	0.5
	p - Nitroaniline - Skin	1	6
	Nitrobenzene - Skin	1	5
	Nitroethane	100	310
C	Nitrogen dioxide	5	9
C	Nitroglycerin - EGDN - Skin	0.2	2
	Nitromethane	100	250
	1-Nitropropane	25	90
	2-Nitropropane	25	90
	N-Nitrosodimethylamine (Dimethylnitrosamine) - Skin	A3	-
	Nitrotoluene - Skin	5	30
	Octane	500	2,350
	Oil mist (mineral)	-	5
	Osmium tetroxide	-	0.002
	Ozone	0.1	0.2
	Parathion (O,O-diethyl O-p-nitrophenyl thiophosphate) - Skin	-	0.1
	Pentaborane	0.005	0.01
	Pentachloronaphthalene - Skin	-	0.5
	Pentachlorophenol - Skin	-	0.5
	Pentane	1,000	2,950
	Pentanone (methyl propyl ketone)	200	700
	Perchloroethylene (tetrachloroethylene)	100	670
	Perchloromethyl mercaptan	0.1	0.8
	Perchloryl fluoride	3	13.5
	Phenol - Skin	5	19
	Phenyl glycidyl ether (PGE)	50	310
	Phenylhydrazine - Skin	5	22
	Phosdrin (Mevinphos) (R) (2-carbomethoxy - 1 - methyl vinyl dimethyl phosphate) - Skin	-	0.1
	Phosphine	0.3	0.4
	Phosphoric acid	-	1
	Phosphorus (yellow)	-	0.1
	Phosphorus pentachloride	-	1
	Phosphorus pentasulfide	-	1
	Phosphorus trichloride	0.5	3
	Picric acid - Skin	-	0.1
	Platinum (Soluble Salts)	-	0.002
	Polytetrafluoro - ethylene decomposition products	-	A4
β	Propiolactone	-	A5
	n-Propyl acetate	200	840
	Propyl alcohol (isopropyl alcohol)	400	890
	Propyl ether (isopropyl ether)	500	2,100
	n-Propyl nitrate	25	110
	Propylene dichloride (1,2-dichloropropane)	75	350
	Propylene oxide	100	240
	Pyrethrum	-	5
	Pyridine	5	15
	Quinone	0.1	0.4
	Rotenone (commercial)	-	5

* Parts of vapor or gas per million parts of air by volume at 25°C. and 760 mm. Hg pressure.
** Approximate milligrams of particulate per cubic meter of air.
A Numbers indicate high toxicity and should be kept at lowest possible levels.
C Ceiling value that should not be exceeded.

Table 1 (Continued)

	Substance	ppm*	Mg/M3**
	Sodium fluoroacetate (1080) - Skin	-	0.05
	Sodium hydroxide	-	2
	Stibine	0.1	0.5
	Stoddard Solvent	500	2,900
	Strychnine	-	0.15
C	Styrene monomer (phenylethylene)	100	420
	Sulfur dioxide	5	13
	Sulfur hexafluoride	1,000	6,000
	Sulfuric acid	-	1
	Sulfur monochloride	1	6
	Sulfur pentafluoride	0.025	0.25
	Sulfuryl fluoride	5	20
	2,4,5T (2,4,5 trichloro-phenoxyacetic acid)	-	10
	Tantalum	-	5
	TEDP (tetraethyl dithiono-pyrophosphate) - Skin	-	0.2
	Teflon (R) decomposition products	-	A4
	TEPP (tetraethyl pyro-phosphate) - Skin	-	0.05
	Tellurium	-	0.1
	1,1,2, 2-tetrachloroethane - Skin	5	35
	1,1,2, 2-tetrachloro-1, 2-difluoroethane	500	4,170
	Tetraethyl lead (as Pb) - Skin	-	0.075
	Tetrahydrofuran	200	590
	Tetranitromethane	1	8
	Tetryl (2,4,6-trinitrophenyl-methylnitramine) -Skin	-	1.5
	Thallium (soluble compounds) - Skin	-	0.1
	Thiram (tetramethyl thiuram disulfide)	-	5
	Tin (inorganic compounds)	-	2
	(organic compounds)	-	0.1
	Titanium dioxide	-	15
	Toluene (toluol)	200	750
	o - Toluidine - Skin	5	22
C	Toluene - 2, 4-diisocyanate	0.02	0.14
	Trichloroethylene	100	520
	Trichloronaphthalene - Skin	-	5
	1,2,3-Trichloropropane	50	300
	1,1,2-Trichloro 1,2, 2-trifluoroethane	1,000	7,600
	Triethylamine	25	100
	Trifluoromonobromomethane	1,000	6,100
	Trinitrotoluene - Skin	-	1.5
	Triorthocresyl phosphate	-	0.1
	Triphenyl phosphate	-	3
	Turpentine	100	560
	Uranium (soluble compounds)	-	0.05
	(insoluble compounds)	-	0.25
C	Vanadium (V_2O_5 dust)	-	0.5
	(V_2O_5 fume)	-	0.1
C	Vinyl chloride (chloroethylene)	500	1,300
	Vinyl toluene	100	480
	Warfarin (3- α acetonyl-benzyl -4- hydroxycoumarin)	-	0.1
	Xylidine - Skin	5	25
	Zinc oxide fume	-	5
	Zirconium compounds (as Zr)	-	5

TENTATIVE VALUES, 1965

The values below will remain in the Tentative List for at least two years to permit presentation of further scientific evidence to indicate their appropriateness for transfer to the Recommended List.

Substance	ppm*	Mg/M3	Substance	ppm*	Mg/M3**
2-Aminopyridine	0.5	2	Bromoform - Skin	5	50
sec-Amyl acetate	125	650	n-Butyl acetate	150	710
Anisidine (o, p-isomers) - Skin	-	0.5	sec-Butyl acetate	200	950
			tert=Butyl acetate	200	950
Azinphos-methyl (Guthion) - Skin	-	0.2	Cadmium (metal dust and soluble salts)	-	0.2
Benzoyl peroxide	-	5	Carbaryl (Sevin) (R)	-	5

* Parts of vapor or gas per million parts of air by volume at 25° C. and 760 mm. Hg pressure.
** Approximate milligrams of particulate per cubic meter of air.
A Numbers indicate high toxicity and should be kept at lowest possible levels.
C Ceiling value that should not be exceeded.

Table 1 (Continued)

Substance	ppm*	Mg/M3**
Carbon black	-	3.5
Carbon monozide	50	55
o-Chlorbenzylidene malononitrile (OCBM)	.05	0.4
C Chlorine	1	3
Coal tar pitch volatiles (benzene soluble fraction) (anthracene, BaP, phenanthrene, acridine chrysene, pyrene)	-	0.2
Cotton dust (raw)	-	1
Crotonaldehyde	2	6
Cumene - Skin	50	245
Cyclohexane	300	1050
Cyclohexene	300	1015
Cyclopentadiene	75	200
Diazomethane	0.2	0.4
C 1, 2-Dibromo-ethane (ethylene dibromide)-Skin	25	190
Dibutylphosphate	2	10
Dibutylphthalate	-	10
1, 3 -Dichloro -5, 5-dimethyl hydantoin	-	0.2
Diethylamino ethanol - Skin	10	50
Dimethyl 1, 2 dibromo-2, 2-dichloroethyl phosphate, (Dibrom) (R)	-	3
Dimethylamine	10	18
Dimethylformamide - Skin	10	30
Di sec. octyl phthalate (Di -2- ethylhexyl-phthalate	-	5
Ethyl amine	10	18
Ethyl sec amyl ketone (5-Methyl-3-heptanone)	25	130
Ethyl benzene	100	435
Ethyl butyl ketone (3-Heptanone)	50	230
Ethylene imine - Skin	0.5	1
C Ethylmercaptan	10	25
N-Ethylmorpholine - Skin	20	94
Fibrous glass	-	5
Formic acid	5	9
Hexachloroethane - Skin	1	10
sec-Hexyl acetate	50	300
Hydrogen sulfide	10	15
Iron oxide fume	-	10
Isoamyl acetate	100	525
Isobutyl acetate	150	700
Isopropyl acetate	250	950
L.P.G. (Liquid Petroleum gas)	1000	1800
Maleic anthydride	-	8
Methyl acetylene-propadiene mixture, (MAPP)	1000	1800
Methylamine	10	12
Methyl n-amyl ketone (2-Heptanone)	100	465
Methyl iodide - Skin	5	28
Methyl isocyanate - Skin	0.02	0.05
Methyl mercaptan	10	20
Methyl methacrylate	100	410
C Methylene bis phenyliso-cyanate	0.02	0.2
C Monomethyl hydrazine - Skin	0.2	0.35
Morpholine - Skin	20	70
Naphthalene	10	50
Nickel, metal and soluble compounds	-	1
Nitric acid	2	5
p-Nitrochlorobenzene - Skin	-	1
Nitrogen trifluoride	10	29
Oxalic acid	-	1
Oxygen difluoride	0.05	0.1
p-Phenylene diamine - Skin	-	0.1
Phenyl ether (vapor)	1	7
Phenyl ether-Biphenyl mixture (vapor)	1	7
Phosgene	0.1	0.4
Phthalic anhydride	2	12
Pival (2-Pivalyl-1, 3 - indandione)	-	0.1
Propane	1000	1800
Propylene imine - Skin	2	5
Rhodium, Metal fume and dusts -	-	0.1
soluble salts	-	0.001
Selenium compounds	-	0.2
Selenium hexafluoride	0.05	0.4
Silver, metal and soluble compounds	-	0.01
Tellurium hexafluoride	0.02	0.2
1, 1, 1, 2 - Tetrachloro-2, 2 - difluoroethane	500	4170
Tetramethyl lead (TML) (as lead) - Skin	-	0.075
Tetramethyl succinonitrile - Skin	0.5	3
Tremolite	5mppcf	-
1, 1, 2-Trichloroethane - Skin	10	45
Xylene	100	435
Yttrium	-	1

* Parts of vapor or gas per million parts of air by volume at 25°C. and 760 mm. Hg pressure.
** Approximate milligrams of particulate per cubic meter of air.

Table 1 (Continued)

RESPIRABLE DUSTS EVALUATED BY COUNT
1965

Substance	m. p. p. v. f. *
SILICA	
Crystaline	
Quartz, Threshold Limit calculated from the formula	$\frac{250}{\%SiO_2+5}$ **
Cristobalite, Threshold Limit calculated from the formula	
Amorphous, including natural diatomaceous earth	20
SILICATES (less than 1% crystaline silica)	
Asbestos	5
Mica	20
Soapstone	20
Talc	20
Portland Cement	50
Graphite	15
"Inert" or Nuisance Particulates	50 (or 15 Mg/m^3 whichever is the smaller)

Conversion factors
mppcf x 35.3 = million particles per cubic meter
= particles per c.c.

* Millions of particles per cubic foot of air, based on impinger samples counted by light-field technics.

** The percentage of crystalline silica in the formula is the amount determined from air-borne samples, except in those instances in which other methods have been shown to be applicable.

with fewer than 500 workers—only a comparative handful have as yet succeeded in establishing in-plant services that go beyond the most elementary provisions for first-aid care".**

It is indeed an unwise and short sighted procedure to attempt to separate the occupational health program from the general health program. This can be understood from the following: 12 to 15% of industrial employees cause 55 to 60% of the time lost in industry by illness, and most of these employees are among the lowest paid workers. The problem thus becomes a general and special problem at the same time. It is general in that the entire working population is affected by industrial hazards and it is special since the bulk of the injuries affect a particular economic group.

Agents Causing Disabilities

A. Physical agents causing disease, or injury.
   1) Extreme dry heat and sudden variations of temperature.
   2) Compressed air chambers.
   3) Electricity.
   4) Excessive sunlight, x-ray, and atomic radiations.
   5) Dampness, cold, and water.
   6) Dust (some of which may be chemical.)
   7) Extreme brightness of light.
   8) Conditions causing wounds to the skin which may lead to infection.
   9) Poor illumination.

B. Mechanical agents.
   1) Repeated motion, pressure, shock, friction, and cutting and abrasive factors.

C. Chemical agents.
   Causing skin or systemic diseases, by direct contact or inhalation, dusts, fumes, mists (See Table 102, Maximum Allowable Concentrations)

D. Biological
   1) Bacteria, fungi, and animal parasites. (Anthrax, Glanders, Undulant fever, Q fever)

Conditions Causing Disabilities

A. Poor facilities
   1) Inadequate illumination and glare.
   2) Inadequate ventilation, temperature and humidity control.
   3) Inadequate toilet and washing facilities.
   4) Poor plumbing, interconnections, cross connections, leaks.
   5) Potentially unsafe water supplies.

B. Lack of safety devices such as in transportation, crane operation, machinery of various types, fires, storage of chemicals and biological poisons, explosions in mines and grain elevators, and a host of other industrial activities.

C. Inadequacies of more general character.
   1) Poor housekeeping.
   2) Inexperienced workers.
   3) Maladjustments caused by sudden introduction of women into certain industries.
   4) Introduction of physically handicapped into industry and failure to fit such workers to jobs that suit their capacilities.
   5) Lack of general physical fitness.
   6) Lack of instruction.
   7) Speeding up machinery and production processes beyond optimum human rhythm.
   8) Overcrowding.
   9) Fatigue.
   10) Inadequate nutrition.
   11) Disturbed transportation and home living conditions.

**The Health of People who Work, edited by A. Q. Maisel, published by the National Health Council, 1964.

Types of Industries and Occupational Illness

In a survey by the United States Public Health Service, the industries found to produce the greatest amount of occupational illnesses were in order of importance, as follows: Food and kindred products; transportation equipment including automobile; iron, steel, and their products; textile mill products and wearing apparel; non-ferrous metals, and their products; garages, laundries, auto repair shops, dry cleaning, etc; chemical and allied industries including petroleum; leather products; lumber products; lumber and furniture, and finished lumber products; electrical machinery; stone, clay and glass products.

The important types of occupational illness found in the survey of 18 states were, in order of prevalence: Dermatitis; conjunctivities; inflammatory conditions due to repeated motion, pressure, or shock; pulmonary and bronchial affections; systemic poisoning: silicosis; pneumoconiosis; lead poisoning; chemical poisoning; chemical poisoning (not specified); undulant fever; nasal ulceration; heat exhaustion; pulmonary tuberculosis; carbon monoxide.

Various types of more commonly known occupational sicknesses:

1) Anthrax
2) Lead poisoning
3) Zinc poisoning
4) Mercury poisoning
5) Phosphorus poisoning
6) Arsenic poisoning
7) Wood alcohol poisoning
8) Poisoning by benzol or nitro-, hydro-, hydrozy-, and amino- derivatives of benzine (dinitrobenzol, anilin, and others)
9) Carbon bisulphide or any sulphide poisoning.
10) Nitrous fume poisonings
11) Nickel carbonyl poisonings
12) Poisoning by Tetrachlormethane or any substance used in conjunction with a solvent for acetate of cellulose or nitro-cellulose.
13) Poisoning by formaldehyde and its preparations.
14) Hydrocyanic acid poisoning
15) Chlorine poisoning
16) Ammonia poisoning
17) Cadmium poisoning
18) Manganese poisoning
19) Chrome ulcer or dermatitis
20) Ulceration or cancerous conditions of the skin or eye surface due to pitch tar, bitumen, mineral oil, paraffin, or any compound product or residue.
21) Glanders
22) Compressed air illness
23) Miners' disease, including boils, carbuncles, joint and tendon disease, hookworm, uncontrollable eye movements.
24) Cataract in glass workers
25) Radium poisoning or disability due to radioactive properties of substances or to X-ray.
26) Poisoning from methyl chloride or other halogenated hydrocarbons
27) Carbon monoxide poisoning
28) Poisoning by sulfuric, hydrochloric, hydrofluoric acid
29) Respiratory, gastro-intestinal, or physiological nerve and eye disorders due to contact with petroleum products and their fumes.
30) Disabilities arising from blisters or abrasions
31) Disabilities arising from joint and tendon diseases
32) Skin disease from contacting various materials
33) Silicosis
34) Asbestosis
35) Cotton disease or mill fever (Byssinosis)

Definitions of terms relating to types of chemical exposures:

Liquid. Fluids characterized by the free movement of molecules but without tendency to

separate from one another as in the case of gases.

Gases. Aeriform fluid having neither independent shape nor volume but tending to expand indefinitely into any volume available.

Vapors. Gaseous materials very near the condensation point or the gaseous form of substances which are normally in solid or liquid state but which vaporize at relatively low temperatures. Vapors tend to diffuse.

Dusts. Finely divided solid particles (0.1 to 150 microns in diameter) formed by the disintegration of solid materials, either organic or inorganic, by such processes as crushing, grinding and abrading. Dusts do not diffuse, they settle according to size and do not usually flocculate in air to any great extent.

Fumes. Very small solid particles formed by physico-chemical reactions, such as condensation of vapors from heated metals and other substances, often accompanied by chemical reactions such as oxidation. Fumes are less than 1 micron in diameter. They flocculate and sometimes coalesce.

Smoke. Liquid or solid particles which are products of incomplete combustion of carbonaceous matter such as coal, wood, oil, gas, or tobacco. Smoke particle sizes range from .001 to 0.3 micron in diameter.

Mists or Fogs. Droplets formed by condensation of vapors upon suitable nuclei or by breaking up a liquid such as by splashing, foaming or atomizing into a dispersed state.

Smog. A popular term which has recently come into use to describe a combination of smoke and fog in the outdoor atmosphere. This term is also applied to complex mixtures of gases, fine particles of dust and liquid droplets. Smogs are characterized by the general murkiness they impart to the atmosphere.

Physical and Mechanical Agents

Light. Glowing materials such as are exposed to the eyes of furnacemen, smelters, electro-welders, and glassworkers cause irritations and burns and may lead to production of cataracts in the eyes.

Heat. Uncontrolled heat to which stokers, smelters, blast furnace men, glass blowers, kiln and pottery workers are exposed may cause heat exhaustion, colic and cramps. Rapid changes of temperature may cause congestion of internal organs with resulting rheumatic, neuralgic, gastro-intestinal, lung affections. Radiant heat may cause skin irritations, eye inflammation and maybe cataract. High temperatures accompanied by high humidity as occurs in breweries, laundries, tanneries, and canneries may cause sweat gland disorders. Cold humid environments, may reduce the individuals' resistance to rheumatic and lung diseases.

Compressed air. Divers and caisson workers are exposed to this hazard. Increased pressure of air causes increased amounts of air to become dissolved in the blood. Sudden reduction of such pressures may cause nitrogen bubbles to form in the blood vessels which may block the blood supply to vital organs and cause sudden death.

Repeated Motion, Pressure, Shock. The use of the same muscles in going through the same motions for many hours may decrease the ability to continue the particular operation although the muscles continue to respond at the individual's will. This is called "occupational neurosis", and may occur to air-hammer operators, tap drummers, cigar rollers, milkers, dancers, letter sorters, people who write over long periods of time, and the like.

Noise. Exposure to excessively loud noises occur in aviation, in wars, in boiler factories, steel mills, textile plants, can factories, pneumatic drilling and the like. The effects of noise are on (1) the ear, (2) the mental process, (3) the body as a whole. Exposure to noise for 4 to 8 minutes at levels of 120 decibels or shorter exposures at higher levels of intensity may cause temporary hearing loss. A noise of 120 to 150 decibels may cause some degree of permanent hearing impairment. Detonations at 160 decibels may rupture the tympanic membrane. It is claimed that reduced intensities of noise increase efficiency and reduce fatigue, and that loud noises are irritating and annoying and interfere with sleep and rest and other bodily functions. When men are exposed to sounds of 150 decibels in the frequency range between 700 to 1,500 cycles per second, the skull, jaws, thoracic wall and large muscle

groups appear to vibrate; dizziness, weakness of the knees, unsteady gait, headache and nausea occur. If continued for some minutes, fatigue, irritability and a sense of apprehension appear. These symptoms all disappear with the cessation of the noise. The effects of ultra-audible sound on man is not yet well known.

Radiation hazards are considered in Chapter XXXII.

Biological Agents Causing Infection

Anthrax is contracted from handling hides, leather and animal hair by such workers as tanners, brush makers, or anyone who handles hides. Such workers should wear gloves. Tetanus, ringworm, and septic infections are common; especially is the latter present among workers who are continually injuring their hands and working in water, such as miners. Metal workers who use oily or soapy liquids to cool metal while it is being cut are also subject to boils and carbuncles, because the oils may be vehicles of pus forming bacteria. Such oils should be sterilized before using. Glanders is a usually fatal infection which is communicated from infected horses and mules.

Dusts, Fumes and Vapors

The size of dust particles is the greatest importance to health. Particles of the size of 10 microns settle out quickly, but particles of 5 microns or less remain suspended in the air for a long time. Particles larger than 3 microns are filtered out in the upper respiratory passages and those below 3 microns may penetrate to the air sacs (alveoli) in the lungs and remain there. The percentage of particles deposited in the alveoli increases as the size decreases from 3 to 1 micron, but the retention decreases as the size decreases from 1 to 0. 25 micron.

Dusts from hard rock or mineral are the pneumoconiosis-producing dusts. Dusts of plant or animal origin are the allergy-producing dusts. Dusts (and fumes) of metal and of other inorganic origin are the ones which may produce toxic effects.

Dust of silica or silicon dioxide are important because they produce silicosis in the lungs which predisposes to tuberculosis. This condition used to be called stone-cutters lungs and is also prevalent in mining, sand blasting, and rock drilling processes. The incidence of silicosis varies depending upon (1) the concentration of dust in the air, (2) the percentage of free silica or silicon dioxide in the air, (3) the duration of exposure, (4) the size of the particles, (5) the presence of other dusts), (6) the individual susceptibility.

Asbestos is a general term applied to minerals of fibrous form. Such dusts produce a form of pneumoconiosis called asbestosis which is somewhat different from that of silicosis in that it does not appear to predispose to tuberculosis, but does lead to secondary respiratory infection and heart involvement. Several other forms of pneumoconiosis are siderosis resulting from exposure to iron oxide dust, and anthracosis resulting from exposure to coal dust.

The three most important plant dusts to which industrial workers are exposed are cotton dust, grain dust and wood dust. Cotton and grain dusts may produce chronic irritation of the lungs, may carry fungi and molds with them into the lungs, and may cause allergies. Cotton disease or mill fever is not uncommon among textile workers. Wood dusts do not appear to be harmful to man.

By the usual type of exposure found in industry (and not in situations where chemical substances are ingested or injected into the tissues):

1) The following metallic dusts and fumes are believed to be relatively harmless: copper, gallium, indium, iron, molybdenum, palladium, platinum, silver (except skin effects), and tin.

2) The following metallic fumes may produce fume fever: zinc and magnesium oxides. Any metallic oxide may produce this effect.

3) The following metallic dusts and fumes may be irritative or produce harmful effects on the respiratory passages: aluminum, beryllium, cadmium, chromium, manganese, nickel, and vanadium.

4) The following metals or their compounds may effect the skin (usually when in the form of a salt with chlorine, fluorine, or sulphur): aluminum, antimony, barium, beryllium, calcium, chromium, copper, magnesium (as splinters), mercury, nickel, potassium, radioactive metals, silver, sodium, zinc, and others.

5) The following metallic dusts and fumes may be absorbed and produce harmful effects in the internal organs: antimony, beryllium, lead, manganese, mercury, radioactive metals, thallium, uranium, vanadium, and others.

Gases in the Air:

These may be classified as:

1) Natural gases which occur normally in the air and produce no harmful effects in ordinary concentrations and pressures.

2) Asphyxiant gases such as carbon monoxide which prevent the tissues from obtaining oxygen.

3) Irritant gases, such as phosgene, nitrous fumes, sulphur dioxide, chlorine, hydrogen fluoride, ammonia, acrolein, ozone, and others which produce inflammatory reactions of the mucous membranes of the respiratory passages and the eyes.

4) Toxic gases, such as hydrocyanic acid, hydrogen sulphide, carbon disulphide, arsine and nickel carbonyl which act as tissue poisons when absorbed.

5) Narcotizing gases, such as nitrous oxide and some organic gases which produce anesthesia of various degrees when absorbed.

Toxic Compounds

1) Arsenic compounds are used in many industrial processes. Arsine gas is dangerous since it has no warning properties. It produces massive destruction of the red blood cells. Arsenic dusts and fumes occur in the manufacture of insecticides and glass, refining of ores, and other industrial processes. They produce dermatitis, respiratory tract irritation, gastro-intestinal irritation, and damage to the nervous system.

2) Fluorine Compounds are used in smelting and refining metals, in ceramic, glass, enamel, chemical and petroleum industries, in the manufacture of insecticides, phosphate fertilizers and welding of stainless steel. These compounds are general protoplasmic poisons. They may burn the skin and eyes or cause marked irritation of gastrointestinal tract and kidneys. Chronic exposure may lead to changes in the bones.

3) Organic Compounds are used in practically every industrial plant no matter how small. These compounds may be produced from the distillation of petroleum which includes such aliphatic hydrocarbons as petroleum ether, gasoline, kerosene, fuel oils, lubricating oils, paraffin, mineral oils, asphaltic pitch, and others. They may be produced from the distillation of coal tars and include such aromatic hydrocarbons as benzene, toluene, naphthalene and anthracene, also various phenols, cresols and a residue of coal-tar pitch. From these basic compounds the various hydrocarbons and their derivatives are prepared. Some of the aliphatic hydrocarbons are gases such as methane, ethane, ethylene, butylene, acetylene, ethyl chloride, etc. Many of the organic compounds are liquids which volatilize readily at room temperature. Because of their solvent properties these compounds are known as volatile solvents. Many of the organic compounds are solids at ordinary temperatures.

Among the organic compounds are most of the recently developed insecticides which may produce poisoning by exposure in the manufacturing process, in the application process, in those who ingest them as spray residues, or in others who come in contact with them.

A considerable number of organic compounds have been shown to cause tumors in laboratory animal. But only a few of these compounds have been proved to cause cancer in man. Cancer of the urinary tract of workers in the organic dye industry is caused by beta-naphthylamine. There is some evidence but no proof that benzidine may also be carcinogenic for the bladder. Cancer of the skin has been reported from exposure to the products of the petroleum industry. It is believed that the carcinogenic substance of paraffin is an aromatic oil. It has been shown that the fractions of petroleum with boiling points above 700° F. exert carcinogenic action. Skin cancer from exposure to tar and pitch have also been reported.

Atmospheric Pollution

This term applies to excessive concentration of foreign matter in the atmosphere which adversely affects the well-being of individuals or causes damage to property, plant, or animal life. Such matter may occur in the form of gases and vapors, or as aerosols composed of finely divided solid or liquid particles which remain suspended in the air. The degree of atmospheric pollution

is greatly influences by weather and topography. The two major weather factors are rain or snow which may remove pollutants from the atmosphere, and air motion by which pollutants may be widely dispersed. Topographical factors such as low areas in deep valleys and inland locations far from extensive water surfaces are favorable for retention of pollutants in the atmosphere. The effect of air pollution on health depends on the character of the pollutant. Generally the effect is on the respiratory system. Smogs have produced mass deaths in humans. Air pollution may cause damage also to vegetation and animal life. It may interfere with the amount of sunlight penetrating to the earth and may cause irritability from vitiation of the esthetic sensibilities.

Occupational Dermatoses.

These are the most numerous and most important of occupational diseases and are responsible for more than half of the occupational disease compensation cases: (1) mechanical and physical factors, (such as heat, cold, ultra-violet, x-ray and other radiation), (2) primary irritants (those which produce dermatitis by direct contact with normal skin), (3) sensitizers (those which sensitize the skin to become predisposed to further contact with the agent), (4) biological agents.

Control Methods

1) Proper building of plants - adequate walls, tight doors, good lighting and ventilation, cleanliness.

2) Arrest poisons, dusts, gases, fumes, etc., at origin by local exhaust system, by rendering them innocuous, by collecting them, by preventing entrance to nose or mouth.

3) General efficient ventilation.

4) Substitution of toxic material by non-toxic materials in the industrial process whenever possible.

5) Wetting of dusts at their origin.

6) Isolation and segregation of harmful operation.

7) Good housekeeping

8) Upkeep of control equipment.

9) Total enclosure of hazardous operations.

10) Avoiding bodily contact with poisons.

11) Process control or introducing new processes for old dangerous ones; proper plant and equipment design.

12) Instruction of workmen, repetition of instructions at frequent intervals.

13) Posting precautionary regulations and warning placards in easily observed places.

14) Increasing personal protection by protective clothes, caps, gloves, goggles, mouth and nose shields, and masks.

15) Promoting bodily cleanliness by making washing, bathing and dressing room facilities easily available; special eating rooms, separate lockers for street clothes, frequent cleaning of clothes.

16) Immediate report of symptoms of indisposition, attention to wounds, available first aid and medical attention.

17) Pre-employment examinations in order to place workers in positions for which they are fit; periodical physical examination; limitation of duration of employment in hazardous work; analysis of medical records in order to detect hazardous conditions; knowledge of plant processes and materials by physicians.

18) Utmost possible reduction of hours of labor in dangerous positions.

19) Periodic environmental survey.

The Industrial Hygiene Program

The Industrial Hygiene Program can be outlined more or less as follows:

1) The promulgation and enforcement of national, state and local laws, rules, and regulations pertaining to the health of the industrial workers.

2) The development and execution of an educational program, aimed at the general public, special groups of workers, legislators, and the staff members of organizations who carry the industrial hygiene program to the people.

3) The organization and supervision of field activities and the provision of consultation service to industry.

4) The distribution and administration of funds for local industrial hygiene activities.

5) The operation of a direct service program consisting of medical, nursing, engineering, sanitarian, chemical, laboratory, and administrative participation.

The specific types of activities may be outlined as follows:

a) Encourage active interest and cooperation between plant officials and employees in all matters relating to health and safety.

b) Receive reports of all occupational diseases occuring in the state.

c) Investigate these diseases to determine their causes.

d) Plan corrective measures to prevent occupational diseases and accidents and provide direct advisory service to eliminate such hazards.

e) Make special studies to determine the influence of occupational conditions upon the health of the workers.

f) Provide advisory service in formulating industrial medical and nursing programs, which include adequate personnel and equipment, preplacement and periodic physical examinations, home nursing service for sick workers, and the proper keeping and analyzing of lost-time records.

g) Provide advice informulating a complete system of medical and hospital service for the workers.

h) Provide direct medical service by health departments for case finding in such diseases as tuberculosis, syphilis, and gonorrhea.

i) Provide free laboratory service for chemical and bacteriological analysis of materials suspected of producing health hazards.

j) Make routine inspection of all industrial, mining, and mercantile establishments for all health aspects including toxic materials, sanitation, heating, lighting, ventilation, and safety.

k) Check industrial construction plans for items relating to health and safety (handling toxic materials, ventilation, sanitary facilities, etc.)

l) Administer a system of workmen's compensation for occupational diseases.

m) Provide speakers to lecture on various occupational hygiene subjects to medical, engineering, nursing, safety, management, labor or lay groups.

n) Provide references and/or printed matter and posters on all phases of occupational health and safety to interested groups and individuals.

In most states the Labor Department is legally responsible for accident studies and safety programs in industry and in just a few are these activities under the jurisdiction of the Health Department. In some states there is excellent cooperation between the Health and Labor Departments on these problems but in others there is constant bickering in regard to jurisdictional rights. The administration of workmen's compensation laws also differs in the various states. This duty is assigned by law to either the Health Department, Labor Department, or a special commission created for that purpose. In some states compensation for accidents and diseases are handled by separate organizations.

Occupational and Industrial Health Regulations

Such regulations should define the various key "terms" used. They should set forth the conditions for approving the plans of construction, alteration or extension of any industrial establishment and its fuel-burning equipment or change in use of such establishment or equipment. They should set forth the conditions under which permits for operation will be issued where special hazards exist, the prohibition of homes for manufacture of explosives, drugs and the like, the investigatory functions of the health officer, the furnishing of reports to the health department, and the employer's responsibility in preventing and controlling hazards.

The following detailed regulations are compiled from the American Society of Mechanical Engineers' recommendation on smoke control, and the Engineering Section Project of the American Public Health Association Proposed Sanitary Code for Louisville and Jefferson County, Kentucky.

Standards and Requirements

General Standards and Requirements

The following requirements are established for the purpose of defining minimum requirements to insure protection of the health of workers, and in the case of atmospheric pollution, also the general population. Nothing herein shall limit the health officer from requiring a higher standard when evidence of the existence of injury to health or the likelihood of injury to health if a condition be allowed to continue requires a more exacting standard.

Failure to meet any of the standards required under General Standards and Requirements,

requirements concerning occupational diseases, requirements concerning treatment under Workman's Compensation Laws, and recommendations for immunizations, shall be cause for suspension and/or revocation of an operating permit held by the owner and/or employer of an industrial establishment. The non-conformance shall be deemed a nuisance and may be abated as such.

Atmospheric Pollution

a. Atmospheric pollution by smoke.

1. Atmospheric pollutants emitted from any fuel-burning equipment, internal combustion engine, premises or open fire shall be controlled to the extent that the shade or appearance of the smoke shall not be equal to or darker than No. 2 of the Ringelmann Chart, (Chart 1) excepting:

(a) Smoke, the shade or appearance of which is equal to but not darker than No. 2 of the Ringelmann Chart for a period or periods aggregating 4 minutes in any 30 minutes;

(b) Smoke, the shade or appearance of which is equal to but not darker than No. 3 of the Ringelmann Chart for a period or periods aggregating 3 minutes in any 15 minutes, when building a new fire or when breakdown of equipment occurs such as to make it evident that the emission was not reasonably preventable.

2. For the purpose of grading the shade or appearance of smoke, the Ringelmann Chart as now published and used by the U. S. Bureau of Mines, which is hereby made a part of the ordinance by reference, shall be the standard.

3. No person shall cause, suffer or allow to be emitted into the open air from any fuel-burning equipment or premises or to pass a convenient measuring point nearest to the stack outlet, dust in the gases to exceed 0.85 lb. per 1000 lbs. of gases adjusted to 50 percent excess air for products of combustion, excepting that for fuel-burning equipment or premises constructed subsequent to the effective date of this ordinance, a dust collecting efficiency of not more than 85% shall be required for special dust-separating equipment, and that for fuel-burning equipment or premises constructed prior to the effective date of this ordinance, a dust collecting efficiency of not more than 75% shall be required for special dust-separating equipment. The limitations given shall be waived during periods when breakdown of equipment occurs such as to make it evident that the emission was not reasonably preventable. The amount of solids in the gases shall be determined according to the Test Code for Dust-Separating Apparatus of the American Society of Mechanical Engineers, revised and amended to date, which is hereby made a part of this ordinance by reference.

4. No person shall cause, suffer or allow to be emitted into the open air from any fuel-burning equipment, internal combustion engine, railroad locomotive, vehicle, premises, open fire, or stack, soot or fumes that are a detriment to the property of others or that are a nuisance to any person not being therein or thereupon engaged.

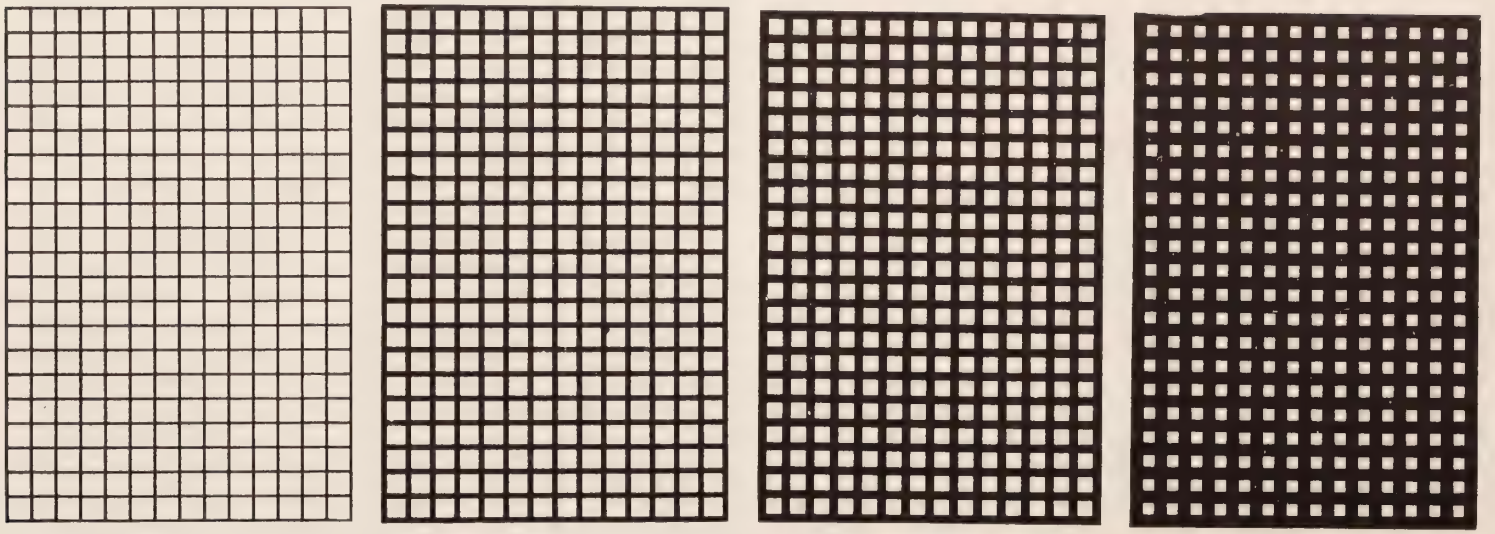
5. After any person of any premises has been previously notified of three or more violations of this Section within any consecutive 12 month period, in respect to the emission of smoke, soot, dust or fumes, the person of these premises shall be notified to show cause before the Health Officer on a certain day, not less than ten days from the date of notice, why the equipment causing such violations shall not be sealed. Upon this date the person may appear and be heard. Upon such hearing, if the Health Officer finds that adequate corrective means and methods have not been employed to correct the cause of such condition, then it shall be his duty to seal the equipment until such time as an Installation Permit and Operating Permit have been applied for and issued for the equipment. The person may, within ten days of this decision, appeal the finding and the appeal shall stay the sealing pending the appeal.

6. No person shall violate the seal on any fuel-burning equipment that has been sealed at the direction of the Health Officer unless authorized by him in writing to do so.

7. Each days violation of this provision shall constitute a separate offense.

b. Other atmospheric pollutants should be controlled if they occur in quantities hazardous to health and tend to:

Chart 1. Ringelman's Scale for Grading the Density of Smoke.



1. Equivalent to 20 percent black 2. Equivalent to 40 percent black 3. Equivalent to 60 percent black 4. Equivalent to 80 percent black

Hang smoke chart on a level with the eye, about 50 feet from observer, as nearly as possible in line with chimney. Glance from smoke to chart and note corresponding number, recording same and time of observation. Repeat observations at one-fourth or one-half minute intervals. From these records the average density may be determined for each hour, or for each day. No smoke is recorded as No. 0. 100 percent black smoke is recorded as No. 5. Experienced observers often record in half chart numbers.

1. Accumulate or condense upon equipment, floors, rafters, ledges, or walls of any workroom in an insanitary or unsafe manner.

2. Provide a fire or explosion hazard.

3. Condense in the air in a manner which will significantly reduce visibility or increase humidity.

c. Except where specifically provided for elsewhere, control of atmospheric pollutants shall be accomplished by any of the following methods:

1. Substitution of a less toxic material for the material polluting the workroom atmosphere

2. Isolation of the operation so that the pollutant does not enter the general workroom atmosphere in hazardous concentrations.

3. Enclosure of the operation so that the pollutant does not escape into the workroom atmosphere in hazardous concentrations.

4. Change of process or operating method (such as by wet methods, the use of foams, colloids, etc.) so that the hazard is controlled.

5. Increase of general ventilation so that the pollutant is diluted to a safe concentration.

6. Exhaust ventilation so that the pollutant is removed from the workroom atmosphere.

7. Any other method approved by the health officer or his agent.

d. Control equipment shall be kept in good repair and in clean condition and shall be operated in conformity with the provisions of this chapter.

e. The latest list of maximum concentrations adopted by the American Conference of Governmental Industrial Hygienists (see Table 1) shall be used as a guide in appraising health hazards and in evaluating control of atmospheric pollutants. The concentrations refer to average concentrations for a daily work shift. Every effort should be made, however, to keep concentrations below these limits for any and all exposures irrespective of the total time of exposure.

f. Atmospheric pollutants not listed in the table shall be controlled within such limits as may be required by the health officer.

g. Those processes or operations using or generating flammable dusts, gases, fumes, vapors, mists, fibers or other impurities shall be completely protected from all sources of ignition.

Infectious Agents

All necessary and effective measures shall be provided to eliminate or control the transmission of infectious diseases through processing or handling industrial products or wastes.

Illumination

The following are requirements for illumination of industrial establishments:

a. Illumination adequate in amount for the type of work shall be provided and distributed to all working areas with a minimum of glare and contrasting light intensity.

b. Seeing tasks requiring discrimination of fine detail under conditions of poor contrast and where the nature of the work is very exacting and prolonged shall be provided with a minimum of 100 foot-candles of illumination.

c. Seeing tasks requiring discrimination of detail over prolonged periods of time and under conditions of poor contrast shall be provided with a minimum of 50 foot-candles of illumination.

d. Seeing tasks requiring moderate discrimination of detail shall be provided with a minimum of 30 foot-candles of illumination.

e. See tasks not involving discrimination of fine details shall be provided with a minimum of 10 foot-candles of illumination.

f. Tasks not requiring critical seeing shall be provided with a minimum of 5 foot-candles of illumination.

g. Efforts shall be made to prevent glare and to avoid excessive brightness ratios between the visual task and its surroundings by eliminating unfrosted, unshielded globes or by any other practical and feasible means.

h. Special vapor proof fixtures shall be provided when inflammable substances are handled or likely to be present in combustible mixture concentrations. The type used shall be one approved by the underwriter laboratories, or other standard acceptable to the health officer.

Ventilation and Temperature

The following are requirements for the general ventilation and temperature of industrial establishments:

a. Air shall be provided and distributed in all working areas as herein required.

b. Outside air shall be provided to all workrooms at the rate of not less than 15 cubic feet per minute per person, or 1 1/2 air changes per hour, whichever is greater.

c. Air circulated in any work place shall be supplied through air inlets arranged, located, and equipped so that workers are not subjected to air velocities exceeding 200 feet per minute except under special circumstances specified in the sanitary code where specifically approved by the health officer.

d. In hot weather where the dry bulb temperature of air exceeds 95 degrees F. in workplaces, the wet bulb temperature measured on an unventilated (stationary) thermometer shall not exceed 82 degrees F. In cold weather the wet bulb temperature in work places shall not exceed 75 degrees F.

e. In offices, the relative humidity shall be not less than 30 percent nor more than 60 percent, and 50 percent shall be considered optimum.

f. A minimum air temperature of 60 degrees F. should be maintained in all work rooms where work of a strenuous nature is performed, and a minimum air temperature of 65 degrees F. should be maintained in all other workrooms unless prohibited by process requirements.

g. Offices shall be heated to at least 68 degrees F. but not more than 76 degrees F. air temperature.

h. Air from any exhaust system shall not be recirculated without written permission from the health officer.

i. Recirculation of air from toilet, shower, wash or restrooms is prohibited.

Local Exhaust Ventilation

The following are requirements for local exhaust ventilation:

a. The air velocity and/or rate of air flow as hereinafter required through a hood, booth, enclosure, or other point of ventilation and through the pipes shall be maintained at all times when the machine or process for which the ventilation is applied is in operation or use.

b. The effectiveness of every local exhaust ventilation system shall be governed by the ability of the hoods, booths or other opening to produce a movement of air towards the opening to transport the contaminant through the system in order to reduce concentrations of atmospheric contaminants to levels within or below those limits shown in Table 102.

c. Piping shall be located so as to be accessible for inspection and maintenance.

d. Ducts for exhaust systems shall be:

1. Constructed entirely of fire resistant materials.
2. Constructed or protected so as to minimize damage from accidental contact.
3. Of adequate strength to meet conditions of service.

e. Air flow equipment including hoods, pipes, fans, motors and collectors shall be effectively grounded.

f. Two or more operations involving more than one substance shall not be permitted to be connected to the same exhaust system when a combination of the substances removed may constitute a fire hazard, an explosion hazard, or otherwise dangerous mixture.

g. Those processes or operations using or generating flammable dusts, gases, fumes, vapors, mists, fibers or other impurities shall be completely protected from all sources of ignition.

h. The capacity of an exhaust system shall be calculated on the basis of all hoods,booths, and enclosures connected to the system being open except where the system is so interlocked that only a portion of it can be operated at a given time in which case the capacity should be calculated on the basis that all the hoods in the group requiring the greatest volume rate of exhaust are open.

i. Air exhaust from any room shall be replaced by an equal volume of air, provided that the air supplied to a room as required above shall be considered in computing the air supply required by this provision.

j. Exhaust systems handling dusts shall be provided with suitable air cleaning devices to remove air contaminants prior to discharging to the outer air, unless otherwise approved by the health officer.

k. The discharge from any exhaust system shall be such that no air contamination therefrom will enter any window, door, or other opening of any work space in quantities sufficient to create a health hazard in such space or create a nuisance or a health hazard in surrounding areas or adjacent premises, and shall be in conformance with the requirements in the chapter on "Housing

for Health."

l. Collected materials shall be removed at intervals frequent enough to insure that the exhaust system will meet the above requirements at all times.

m. Collected materials shall be disposed of in a manner which will not result in a nuisance or health hazard, and in a manner conforming with the provisions under Refuse Disposal.

n. See Chapter on Radiation Hazards.

Personal Protective Equipment

The following are requirements for personal protective equipment:

a. Personal protective equipment shall not be used in lieu of control measures specified under General Standards and Requirements above, except when approved by the Health Officer.

b. Whenever substances, radiation or mechanical irritants are encountered which are capable of causing any pathological change or injury to the body or impairments in function of any part of the body through skin or mucous membrane absorption, personal protective equipment and/or protective barriers such as skin creams shall be provided.

c. When the wearing of personal protective equipment is necessary for worker protection, the employer shall provide and fit to each exposed employee such equipment as may be required and shall maintain the same in an efficient and sanitary condition.

d. Where the process in which the worker is engaged is such that his working clothes may become wet or have to be washed between shifts, they shall be so cared for that dry clothes are assured for the return to work.

Plant Housekeeping

The following are requirements for plant housekeeping:

a. All places of employment, passageways, storerooms, service rooms, machinery, equipment, and supplies shall be kept in a clean and sanitary condition with all unnecessary dust, spillage, and debris removed at regular intervals frequent enough to maintain good housekeeping.

b. Where wet processes are used, reasonable drainage shall be maintained and false floors, platforms, mats, or other dry standing places shall be provided, and shall be kept clean as required by the health officer.

c. So far as possible, sweeping and cleaning shall be done in such a manner as to avoid the contamination of the air with dust during working hours.

d. Every floor, working place, and passageway shall be kept free from protruding nails, splinters, or holes, and loose boards, loose articles or metals likely to cause stumbling, tripping, slipping, or body injury.

Plant Sanitation

The following are requirements for plant sanitation:

a. There shall be provided in all places of employment an adequate potable water supply, approved by the health officer as to source and distribution in accordance with the provisions of this Code.

b. Drinking facilities readily accessible to all employees and of a type approved by the health officer shall be provided in the ratio of one facility for each 100 employees.

c. Expectorating within the place of employment shall not be permitted except into facilities acceptable to the health officer as to type and maintenance.

d. All waste incident to operation of the place of employment shall be collected, stored, and disposed of in a manner not to be a hazard to health nor a nuisance to the employees and in conformance with the provisions of this Code.

e. Effective measures shall be taken to prevent the entrance or harborage of insects, rats, or other vermin within the working environment in accordance with the provisions of this Code.

f. Every place of employment shall be provided with adequate water closets conveniently located and separate for each sex according to requirements in "Chapter on Plumbing."

1. Covered waste receptacles for the disposal of sanitary napkins shall be provided in all toilet rooms for females.

2. Toilet paper shall be provided for each water closet.

g. Construction and ventilation of toilet rooms, and construction and installation of toilet facilities shall conform with the requirements of the health officer and shall be in conformance with the construction requirements for such rooms.

h. The disposal of all liquid wastes shall conform to the provisions of this Code for either sewage or industrial liquid waste or both.

i. Sanitary plumbing in an industrial establishment shall be in conformance with the provisions in the chapters on "Plumbing" and "Housing for Health. "

1. Sanitary plumbing shall connect with industrial drainage piping only through an industrial connection sewer or a building sub-drain, unless otherwise specifically acceptable to the health officer.

j. Every place of employment shall be provided with minimum washing facilities in accordance with requirements in the chapter on "Plumbing. "

1. Individual towels of cloth or paper shall be provided. Other apparatus for drying the hands may be substituted only after approval by the health officer.

k. A minimum of one shower bath with ample supply of hot and cold water from one fixture shall be provided for every 15 employees exposed to excessive heat, or to skin contamination with toxic, poisonous, infectious, or irritating material.

1. Each toilet room and wash room shall be provided with a proper metal receptacle for refuse disposal.

m. Dressing rooms acceptable to the health officer shall be provided adjacent to shower rooms for employees whenever the type of work performed involves exposure to excessive dust, dirt, heat, fumes, vapor, or moisture, of such degree as is declared by the health officer to require the provision of dressing rooms.

n. Suitable lockers shall be provided in a room separate from the place of work for employees whose clothes are exposed to contamination with poisonous, infectious, or irritating material, and well separated facilities shall be provided for street and working clothes.

o. The layout and maintenance of toilet rooms, shower rooms, and change rooms in any industrial establishment not governed under regulations for food handling shall be in conformance with the provisions for facilities established for such rooms in bathing places.

1. The health officer may accept such variations in layout as are practicable and feasible for a particular establishment provided that no reduction in protection of the health of workers would result by such variation, and provided that such variations be stated in writing.

Plant Service Facilities

The following are requirements for plant service facilities:

a. Where 10 or more women are employed at any one time, at least one retiring room for their exclusive use shall be provided.

b. Where less than 10 women are employed and a retiring room is not furnished, some equivalent space shall be provided which can be properly screened and made suitable for the use of women employees.

c. The minimum space provided for a retiring room for 10 women shall be 60 square feet. The minimum increased space for more shall be at least 2 square feet for each additional woman employed.

d. At least one couch or bed shall be provided in every place where more than 10 women are employed. The number of such beds or couches required shall be as follows:

10 to 100 women	1 bed
100 to 250 women	2 beds
	1 bed for each additional 250 women employed.

e. In all places of employment where employees are permitted to lunch on the premises, an adequate space suitable for that purpose shall be provided for the maximum number of employees who may use such space at one time.

f. No employee shall be permitted to partake of any part of his lunch or eat other food at any time in any place where there is present any industrial poison or other substance that may be injurious to the employee's health.

g. In every establishment where there is exposure to injurious dusts or other toxic materials, a separate lunch room shall be maintained unless it be convenient for the employees to lunch away from the premises.

h. Where lunch room, cafe, or cafeteria is provided within the plant, it shall be constructed, maintained, and operated to conform with the requirements and provisions for food handling.

i. The circulation of food vendors in any part of a plant where there is present any industrial poison or other substance that may be injurious to the employees' health shall be prohibited.

Medical Standards and Requirements

The following requirements are established for the guidance of the health officer in securing adequate, proper, and necessary medical supervision, and treatment sufficient for the protection

of the health of individual workers, and the health of other plant employees.

Whenever the word "shall" is used, the provision shall be mandatory and whenever the word "should" is used, the provision should be conformed with when feasible and practicable, and with the understanding and cooperative effort of both employer and employee or prospective employee or any other person concerned.

Physical Examination

a. Industrial health examination by a licensed doctor of medicine should be provided for every employee on a preplacement and regularly scheduled periodic basis.

b. The doctor of medicine making the physical examination should acquaint the examinee with the nature of any disease or defect noted.

c. Records of such examinations shall be confidential records of the doctor of medicine. Access to individual's record shall be granted only on request or consent of the examinee with the following exceptions:

1. The employer should be given a medical opinion or rating as to employability and recommendations as to suitability of placement.

2. When required by law.

Occupational Diseases.

a. Any disease resulting or suspected to be caused by exposure to a hazardous environment shall be reported by the physician treating the case to the health officer with an opinion as to character of the hazard suspected. Any such disease should be reported by the physician treating the case to the employer.

b. Whenever two or more occupational disease cases reported as above are suspected of resulting from the same cause in the same industrial establishment, the health officer shall investigate the circumstances of each case and shall cause to be made such medical and engineering examinations of the suspected hazardous condition and of other employees having a suspected or possible exposure as may be deemed necessary to ascertain the full extent and effect of such condition on the health of employees of such establishment.

1. Whenever a hazard injurious to health is determined to exist, the health officer shall require all measures necessary to control the hazard.

Immunization and Treatment

a. Provision for treatment of occupational diseases shall be in accordance with Workman's Compensation Laws. The employer should make provision for treatment of all occupational accidents and disease whether or not required by Workmen's Compensation Laws.

1. Treatment shall be administered by or under direction of a licensed doctor of medicine.

b. At every place of regular employment facilities shall be provided for the prompt emergency treatment of occupational accident or disease. Equipment and supplies shall be approved by a licensed doctor of medicine.

1. Services of trained first aiders or nurses shall be under supervision of a licensed doctor of medicine.

2. Each first aider or nurse shall be provided with written standing orders signed by the doctor of medicine.

3. Plants should have qualified nursing service in quantity required by the hazards and demands for service, and it is suggested that full time nursing services should be provided in plants having 500 employees or more.

4. Plant nurses, when provided, should work closely with the nursing service of the health department.

c. Similar facilities and services should be available for emergency treatment of any non-occupational accident or disease.

d. Evidence acceptable to a doctor of medicine of successfull smallpox vaccination within the preceding five years should be a general requirement for employment.

Miscellaneous Hazard Protection Requirements

The following requirements shall be in addition to all other requirements of this chapter.

a. Tobacco, cigars, or cigar bands shall not be brought to the mouth in the process of manufacture or banding cigars or other products of tobacco.

b. The point where electric welding is being conducted shall be so enclosed that harmful rays

from the arc will not reach the eyes of any workman.

c. Any person engaged in fumigating or in using cyanogen compounds or 1080 or any other gases, vapors, fumes or liquids which are dangerously toxic shall have a specific permit issued by the health officer for each such fumigation or use. The permit shall be issued only when all protective measures for the employee, the premises occupant, or any animal, pet or person likely to have access to such premises are provided and are satisfactory to the health officer.

d. Floors and other surfaces of any room where lead is used or handled, shall have smooth, even surfaces, permitting an easy removal of dust by vacuum cleaning, or by flushing the floor with water, or by sweeping after the floor has been sprinkled with water or wet sawdust or other wet non-poisonous material sufficient to lay all dust.

1. Dry sweeping of such floors or walls or surfaces shall be prohibited.

2. All equipment in such rooms shall be carefully cleaned by vacuum, if necessary, to prevent the accumulation of lead, lead dust, or dirt containing lead.

e. No permit shall be issued for an establishment which manufactures or stores any explosive or any dangerous or inflammable chemical within the limits of any incorporated community, unless the health officer be presented with evidence that no danger to health of occupants of the premises or residents in the immediate neighborhood or a nuisance may or is likely to result, and in no event shall such permit be issued when the establishment is to be located in a place prohibited for such use by the zoning commission or by the building inspector.

f. In any establishment where employees are required to mix dry lead, or dry compounds containing lead in excess of 10 percent the employer shall:

1. Provide one lavatory for each five such employees separate and apart from work rooms in a separate wash room from any other. Each lavatory shall be supplied with hot and cold running water and shall be of a type acceptable to the health officer. All such lavatories shall be supplied with an ample supply of soap. Each employee shall be provided with clean cloth towels as often as may be necessary, and not less than three times per week, or with sanitary paper towels.

2. Permit every employee a time allowance not less than 10 minutes before lunch and the close of work, for the purpose of thoroughly scrubbing hands, face, and exposed skin. Nail brushes, clean, disinfected, and in good condition shall be provided for the individual use of each employee.

3. Supervise employees sufficiently to assure that hands and other exposed skin are washed and to be sure that no unnecessary transfer of lead, dust, or dirt containing lead outside the work room and change room occurs.

g. All spray painting with harmful materials shall be done in booths having a hood face air flow velocity of 150 LFM (lineal feet per minute) toward the vent, or room booths having an air change once each two minutes, except under the following conditions, in which cases the sprayer shall be provided with and shall use an approved respiratory protector:

1. The spray painting of interiors or exteriors of buildings or of other structures.

2. The spray painting of objects in the open air or in sheds open on at least two opposite sides.

3. The spray painting of large castings, forgings, structural members, parts of machinery, or other large objects, if not readily subjected to booth treatment.

4. The spray painting of exceptionally large objects such as railroad cars and trolley cars.

5. The retouching of automobile parts after repairs, or similar minor or intermittent use.

6. Other conditions when permission is granted by the health department.

(1) These exceptions shall not be applicable to indoor spraying if more than one pint of material to each 1,000 cubic feet of air space be sprayed per hour unless natural or artificial ventilation be provided.

(2) Under no conditions shall these exceptions be applicable to the interior coating of vaults, cellars, shafts, tanks, or similar confined and unventilated spaces unless artificial ventilation equivalent to five air changes an hour be maintained.

(3) All workmen exposed to the material being sprayed or vapors thereof shall be protected in a manner equal to that afforded the spray operator. Where it is impracticable for such workmen to wear respiratory protectors, that portion of the room used for spraying shall be separated by walls from the remainder of the room where the other workmen are employed.

(4) Storage supplies of flammable materials used for spraying, when kept in rooms in which spray operations are being carried on, shall be kept in tightly closed containers. Every liquid supply tank shall be provided with a metal cover which shall be kept in place at all times

except when removed for filling or cleaning.

(5) The amount of flammable spraying materials kept in rooms in which spray operations are being carried on shall not exceed an amount necessary for one day's work except where material is sprayed directly from original drum containers. All empty drums or other containers shall be promptly removed from all booths and room booths and areas immediately adjacent thereto.

(6) Tanks or other containers used in connection with spraying operations shall be so constructed, located, and operated as to minimize the possibility of their being upset and the contents spilled. Gravity tanks shall be supported by non-combustible materials. Gravity tanks supported by wire cables or chains shall not exceed 10 gallons in capacity.

(7) If materials be sprayed from original drum containers, pressure in excess of 10 pounds per square inch shall not be used to force such materials from the containers.

h. Public garages shall be provided with a means of general ventilation which will deliver not less than three air changes per hour when garage doors are closed.

a. Additional local ventilation piping, flexible and attachable to the tail pipe of any automobile or other motor driven vehicle and capable of providing not less than 100 c. f. m. per auto, 200 c. f. m. per gasoline engine truck, 300 c. f. m. per Diesel truck, shall be provided and used on any vehicle allowed to stand with the motor running inside a garage for more than one minute.

(1) Such ventilation shall connect with vents leading to the outside air.

(2) Flexible tubing shall be free from leaks and in good repair and shall not be less than 2 1/2 inches in diameter when the tube is 15 feet or less in length. Longer tubes shall be larger.

b. No apparatus nor machine reputed to remove or extract carbon monoxide from the atmosphere shall be acceptable as a substitute for the air exchange requirement and general ventilation or local exhaust ventilation above required.

i. No nitrocellulose film shall be used or permitted to be used or stored in any hospital, institution, doctor's office, x-ray laboratory or any similar place or institution.

Acetate cellulose film, when stored in quantity in such places or institutions, shall be stored in a steel, fire-resistant filing cabinet, or in a fire-resistant filing cabinet, or in a fire-resistant storage room vented to the outside air.

j. Owners, operators, construction contractors, and employees of sewerage systems, sewage treatment plants, and sewage works shall employ all necessary safeguards to eliminate or reduce occupational hazards in such works and shall follow as closely as practicable and feasible all recommended practices established in the Federation of Sewage Works Associations Manual of Practice No. 1, published in 1944 and titled, "Occupational Hazards in the Operation of Sewage Works."

k. No person shall paint any toy intended for use by children with paint, varnish, or enamel or other coating containing lead in any form.

l. The use of mercurial carrot in the preparation of hatters' fur or the use of mercurial carroted hatters' fur in the manufacture of hats, is prohibited.

m. Construction contractors engaging in any hazardous construction producing or likely to produce injury or operating in the presence of any toxic substance, or any occupational health hazard shall be governed by the provisions under General Standards and Requirements of this Chapter.

n. Caisson work shall require special approval of all protective measures and the conditions of work to be determined by the health officer on the basis of each individual construction undertaking.

Special Requirements for Dry Cleaning Establishments

In addition to the requirements set forth under Standards and Requirements, all dry cleaning establishments shall meet the following requirements:

a. Each dry cleaning unit shall bear a label of the manufacturer specifying the type of solvent for which it is designed. The use of a solvent in any dry cleaning unit other than a solvent of the type for which such unit is designed is hereby prohibited.

b. No solvent shall be received or stored in a dry cleaning plant except in containers bearing a suitable warning label, meeting the approval of the health department.

c. No solvent shall be used in any dry cleaning machine or system designed for non-inflammable solvent that does not remain non-flammable under all conditions and processes to which it is subjected during the normal operation of the machine, including evaporation, drying and distillation.

d. Where flammable solvents are used, all operations, dry cleaning machines or systems, equipment, and buildings shall conform to the applicable building codes and fire prevention codes and zoning commission requirements.

e. All liquids, including still residue, and all solids, such as filter residues shall be stored and handled in such a manner as to minimize evaporation and spillage; and storage containers for such liquids shall be air-tight. All residues containing solvents shall be disposed of in such a manner that they do not create a health or fire hazard or violate provisions of this Code.

f. All solvent shall be transferred directly from drums to the storage tank or other parts of the machine by means of gravity flow, or by pumping, through a pipe or suitable hose using the pump on the machine or an auxiliary pump suitable for the purpose. The transfer line shall be free of leaks and handled in a manner to avoid spillage.

g. All dry cleaning machines and equipment, using organic solvents, shall be so designed, installed, and operated as to prevent the escape of excessive quantities of solvent (as established by the health officer), either as liquid or vapor, into the workroom when such machines and equipment are in normal state of operation and repair.

h. The machine shall be so designed and operated that solvent-laden garments shall be sufficiently free of solvent when removed from the drying tumbler or cabinet, that the residual solvent thereon, if any, does not create in the working space excessive quantities of vapor as defined above.

i. When dry cleaning equipment is installed in an enclosure of any type for the purpose of preventing the breathing of excessive quantities of solvent vapor by the operator or other persons in the workroom, the said enclosure shall be equipped with a system of mechanical, automatic ventilation of sufficient capacity to prevent the occurence in the working space of excessive quantities of solvent vapor.

j. All such installations shall be designed, constructed and operated so that the operator need not enter the enclosure to carry on any of the operations of dry cleaning and of drying the garments after removal from the washing or extracting apparatus. The enclosure shall be provided with a ventilated opening or openings of adequate location and size through which all cleaning and drying operations can be carried on by the operator from a point outside of the enclosure.

k. An air movement of not less than 100 LFM (lineal feet per minute) shall be maintained at all openings of the dry cleaning equipment enclosure. The air movement shall be from the adjacent workroom into the enclosure and out of the enclosure through an opening leading to the mechanical ventilation device provided.

l. All enclosures shall be so designed that the exhaust fan may be started without entering the enclosure. Air movement provided for in k, above, shall be automatically maintained whenever the enclosure is occupied.

m. When dry cleaning equipment is designed or operated in such a manner that solvent-laden garments are transferred in the workroom from one piece of equipment to another, mechanical ventilation shall be provided so as to impart an air movement of not less than 100 LFM away from the breathing zone of the operator throughout the area of transfer, and into an exhaust duct as provided below. Such ventilating equipment shall be in operation whenever garments are transferred.

n. All vent pipes, ducts, or flues, which conduct solvent vapors removed from the dry cleaning equipment and processes, shall have vapor-proof joints and shall discharge out-of-doors at such a point that excessive quantities of solvent vapors as defined will not be inhaled by occupants of the building or of adjoining buildings. Backdraft eliminators shall be provided.

o. The outlets of all vent pipes carrying solvent vapor shall be above the roof level if possible; or may be into suitable areaways or alleyways that are not closed on more than two sides and less than 20 feet in width when such venting does not create a hazard or a nuisance affecting adjacent premises.

1. Roof-level vent-pipe outlets discharging solvent vapors shall be at least 20 feet from any wall of an adjacent taller building, if such wall contains windows or ventilating inlets.

2. Outlets of vents discharging solvent vapors at one wall of an areaway or alleyway shall be at least 20 feet from any other bounding wall that is not in the same general plane as the one containing the vent, if such other wall contains windows, doors, or ventilating inlets.

p. The health officer may exempt from the provisions under o, above, any dry cleaning plant the ventilating system of which is so installed and operated as to prevent quantities of solvent vapors from being inhaled by occupants of the building or of adjoining buildings in excess of those defined.

q. Any direct-fired heating apparatus shall be equipped with a corrosion-resistant flue and draft hood which shall conduct the products of combustion outdoors.

r. Workroom ventilation, either natural or mechanical, shall be provided at all times for the workroom to prevent excessive quantities of solvent vapor as defined above, from developing in the working space during normal operations or in emergency situations.

s. All employees engaged in the operation or maintenance of dry cleaning equipment shall be fully instructed, and notices shall be posted in conspicuous places, in the safe operation of such equipment under routine and emergency conditions.

t. Workers performing any operation of maintenance or repair that may lead to excessive quantities of organic solvent vapor in their breathing zone shall be protected with respiratory protective equipment by the employer which is maintained in a clean, sanitary condition and in good operating order.

u. In addition to the requirements set forth under Standards and Requirements, all laundries shall meet the following requirements.

1. Any laundry using any materials for dry cleaning, spot cleaning or other cleaning where such solvents are required shall conform with all applicable requirements under Special Requirements for Dry Cleaning Establishment.

2. Materials to be washed, dried, ironed, or handled within a laundry shall be protected from contamination from any source by whatever means required by the health officer.

Sampling Apparatus

Many methods and apparatus for sampling air contaminants have been developed. These can be summarized as follows:

For Air-Borne Particles (Dust, Fumes, Mist, Smoke)

Sedimentation: The settling of dust upon an open pan or plate is not a good measure of the concentration of dust in the air, since the air is constantly in motion and the volume of air from which the dust settled is unknown.

The closed cell, such as the Green Sedimentation Cell consists of a cylinder of known height and volume with spring covers which can be quickly closed. The open cylinder is waved through air, the covers then quickly closed to trap a known volume of air. The dust is then allowed to settle out. Particle sizes of less than 0.2 micron cannot be collected by this method.

Impingement in Liquid. The Greenburg-Smith Impinger is, essentially, a glass cylinder, 30 cm. high and 50 mm. in diameter, having a long concentrically (inside center) located tube (as the inlet,) extending from the top of the cylinder and ending in a jet a few mm. from the flat bottom. The outlet connection is at the top of the cylinder at which point the suction is applied which draws air down the inlet tube, through the jet, and forces it to impinge against the bottom of the cylinder. The cylinder is filled to depth of several cm. with collecting fluid (usually water, although various solvents can be employed such as alcohol, glycerine, analytical solutions of acids and alcoholics.) Dust particles are momentarily arrested by the impingement process, wetted by the liquid, and thus trapped. Any gases soluble in the absorbent are also collected. The size of the orifice, the air velocity through the orifice, and the distance from orifice to bottom (or impingement plate) are critical factors in the impingement process. The collecting efficiency falls off rapidly for particles smaller than 0.7 micron. It has a sampling capacity of 1 CFM (cubic foot per minute). This has been the standard sampling instrument in the United States. The Midget Impinger is a smaller version of this model which can be carried easily from the shoulder and has a sampling capacity of 1/10 CFM. Dust particles such as silica, asbestos, talc, cement, etc. are actually counted in a standard cell (similar to counting red blood cells) and the concentration is expressed as millions of particles per cubic foot (m.p.p.c.f.) of the air sampled. Chemical dusts or metal dusts are analyzed and the concentration expressed as milligrams per cubic meter of air.

The Flask Impinger consists of a pump and blower, delivering a stream of compressed air through a glass tube (called the impinger) into a calibrated flask at the standard sampling rate of one cubic foot per minute. The collecting medium in the flash may be triple distilled water, dilute alcohol, or 95% alcohol, according to the necessity of the sampling conditions.

Impactors. When a high velocity, dust-laden stream of air strikes a flat surface at right angles, the sudden change in direction of air flow and the momentum of the dust particles result in the separation of the dust from the air. The air passes on, leaving the particles adhering to the surface. Instruments using this principle usually are efficient in collecting particles larger than 0.5 micron in diameter. Several instruments for sampling dust have been developed, based on this principle, such as: The Konimeter, having a tapered nozzle through which a stream of outside air is drawn by a pump to impinge on a circular glass plate; the Owens Jet Dust Counter, being essentially the same as the Konimeter but having a rectangular nozzle; the Bausch and Lomb Jet Dust Counter being similar to the Owens instrument; and the Cascade Impactor, consisting of 4 impingement slits of decreasing width connected in series and mounted at decreasing distances above the collecting plate, allowing for different size particle collection.

Filtration. Tubes of volatile or soluble crystals, such as salicylic acid, sugar, naphthalenes, etc., have been used as methods of dust collection by drawing and filtering the contaminated gases through them. The dust is recovered either by volatilization or dissolving of the crystals whose purity is sufficient not to leave a residue with the dust collected.

The Millipore or molecular filter is a thin (150 (microns) sheet composed of mixed cellulose esters. It can be manufactured in a variety of pore sizes and resistances with great uniformity. The significant advantages are that: (1) the penetration into the filter, even by the smallest particle, is very slight (10-20 microns); (2) it is readily soluble in organic solvents such as acetone and ethyl acetate (and therefore can be used to collect samples for the electron microscope); (3) accurate and reproducible measurements of light reflected from the collecting surface can be made (due to membrane uniformity), thus sometimes eliminating tedious chemical analysis; (4) its high purity makes chemical analysis of the specimen simpler; (5) and its small size and slight affinity for water makes accurate weighing possible. When the collected sample is placed on a microscope slide and moistened with immersion oil of the same refraction as the filter, the filter becomes transparent and the particles can be seen in one plane.

The Whatman extraction thimble operates by fitting it securely into a hole in the top of an air tight box which is attached to a suction source. The air enters the box through the thimble which retains the dust.

Alundum thimbles and sintered glass filters are made in a variety of porosities. They have considerably higher resistance to air flow than comparable paper filters, and can be used for high temperature sampling.

Discs of chemical grade filter paper mounted in suitable holders have been shown to have high retention efficiencies.

Special pleated filters are sometimes used with a portable vacuum cleaner type pump which permit sampling rates up to 80 cubic feet per minute.

Centrifugal Separators. Small scale, high velocity cyclones, models of the large cyclone dust collectors used in industry have been proposed as air sampling instruments. The efficiency of the instrument is good only for large particles (greater than 5.0 microns.)

In the Spiral Sampler, the dust-laden airstream is drawn through a channel of decreasing width which is curved in an Archimedes' spiral. This instrument is nearly 100% efficient for collecting particles larger than 0.5 microns.

The Conifuge is a conical self-pumping electric-driven centrifuge into which the dust is drawn by an internal circulation of previously cleaned air. The size of particles collected ranges from 30 to 0.5 microns.

Spray Techniques. The Venturi Scrubber is a device based on the introduction of a water spray by a nozzle into a Venturi through which the dust-laden air passes at high velocity. The dust and fume particles are wetted by the water spray and the droplets of water containing the dust particles are collected by means of a cyclone or other device.

Electrostatic Precipitation. This is a commonly used method and consists of a grounded metal cylinder about 1.5 inches in diameter and 6 inches in length which serves as the collecting electrode. Located concentrically in the cylinder is a stiff wire electrode which is maintained at either a positive or negative potential of about 12,000 volts. The small radius of curvature of the wire produces a very intense electric field around it, causing a corona discharge between the wire and the collecting cylinder. Dust particles subjected to this discharge become highly charged and attracted toward the cylinder wall where they are collected. Even at relatively high air flows (3 cubic feet per minute) an efficiency of nearly 100% for all sizes of particles can be expected.

Thermal Precipitation. This is based on the principle that a dust-free area exists around a hot wire. The air to be sampled is drawn through a narrow slot by means of a water aspirator across which a hot (100° C.) nichrome wire is located. The sides of the slot are formed by 2 microscope cover slips which are kept cool by contact with brass cylinders holding them in place. The dust particles approaching the wire are forced against the cover slips by the high thermal gradient (4000° C. per cm.) and collected. The instrument is highly efficient, especially for particles smaller than 5 microns, and can easily be used to collect specimens for electron microscopy.

Gas and Vapor (Molecular size particles)

The two basic methods for collection of gaseous samples are, firstly, the use of a gas collector such as an evacuated flask or vacuum bottle to obtain a definite volume of air at a known temperature and pressure, the collector being resealed immediately to prevent any loss before analysis; and secondly, the passage of a known volume of air through an absorbing or adsorbing medium in a U-tube, fritted glass bubbler, or impinger to remove the desired contaminants. The selection of one or the other technique depends upon the type and purpose of a particular sample. When the major components of a gas or of air are to be determined, a gas collector is used. When a minute quantity of a contaminant must be estimated, the absorbing or adsorbing method is used — usually with silica gel or activated carbon with color reacting chemicals giving direct calibrated readings. Special testers are available that give direct readings, at the sampling site, by comparison with color standards or the amount (length) of color change in standard tubes: these are made for testing the concentration of carbon monoxide, hydrogen sulfide, nitrogen dioxide, sulfur dioxide, and aromatic hydrocarbons.

Combustion Chambers. The Davis Halide meter measured the concentration of carbon tetrachloride vapor by converting vapor combustion heat to galvanometer reading. The Carbon Monoxide Meter measured CO concentration by the measurement of heat produced in catalytic combustion. ($2\,CO + O_2 \longrightarrow 2\,CO_2 +$ heat).

Photolectric Measurement. Ultra-violet Light Device can be used to measure mercury vapor by noting resistance to the passage of a beam. Infra-red Light Device measures carbon monoxide by converting light beam obstruction to electrical impulses. Ionization Method measures decrease in conductivity of treated gas sample caused by removal of ions by the particulate, the gas having been converted to an aerosol before introduction to the ionization chamber.

Microorganism Sampling is done by impinging air on impingement plates, by use of membrance or Millipore filters, and by impinging air on a special agar cylinder (Wells Air Centrifuge).

With few exceptions, these instruments do not trap all air-borne particles, i.e., those in the range smaller than 0.5 micron. Therefore the values obtained are not of the greatest precision. Particles larger than 5 to 10 microns do not readily get into the respiratory track, while those below 0.1 micron do not cause as much trouble as the particles in the range of 0.1 to 5.0 microns. Thus, the maximum allowable concentrations of air pollutants are based on the measuring abilities and results obtained with these instruments as related to clinical evidence of disease.

Chart 2
AIR POLLUTANT RESUME

Type of Pollutant	Effect	Source	Possible Control Measures	Air Pollution Sampling Method
Fallout Particulate Matter	Soiling of property, nuisance	Industry, combustion processes, road mix plants, incinerators. etc.	Cyclones, bag filters, electrostatic precipitators, washers, etc.	Dustfall sampling Use of glass slides
Suspended Particulate Matter, Smoke	Soiling of property, visibility reduction, nuisance, health effects	Industry, combustion processes, road mix plants, incinerators, etc.	Bag filters, electrostatic precipitators, good combustion practices	1. High Volume Filter Sampler 2. AISI Smoke Sampler 3. Visibility Determinations
Hydrocarbons	Primary contributors to Los Angeles type smog (eye irritation, rubber cracking, visibility reduction, oxidant formation, plant damage).	Automotive vehicles, oil refineries, fuel handling, solvent handling.	Automotive exhaust control devices and blowby devices, floating roof covers, vapor recovery systems	Flame ionization
Oxides of Nitrogen		Automotive vehicles, combustion processes, industry	Automotive emission control devices, controlled combustion	Saltzman method
Oxidant (a measure of Los Angeles smog)	Eye irritation Rubber cracking Plant damage	Photochemical reactions in the atmosphere	Controls for hydrocarbons and oxides of nitrogen	Potassium iodide method
Carbon Monoxide	Toxic pollutant Reduces visual and mental acuity	Automotive vehicles Incomplete combustion	Automotive exhaust devices (under development) Good combustion practices	A modification of the NBS colorimetric detector tube technique
Sulfur Dioxide	Corrosive, odorous, plant damage, health effects	Combustion processes, industry, etc.	Absorption towers, control of sulfur content in fuel	West-Gaeke method
Pollen	Allergy, hay fever	Natural-trees, grasses, weeds, etc.	Farming methods, weed control	Collection on slides
Odors	Nuisance	Industry, sewage and water treatment, open burning, etc.	Good housekeeping, chemical control, masking counteractant, afterburners, etc.	Trained observers Panel of observers Volunteer observers

Chart 3. Air Pollutants

TYPE	EFFECT	SOURCE	CAUSE	POINT OF EMISSION	METHOD OF CONTROL	ENFORCE-MENT MEASURES	COM-PONENT
AGRICULTURAL SPRAYS	toxic irritation	agricultural spraying	spray drift	spraying apparatus	good judgement	ordinances & regulations	solid & gas
VOLCANIC ASH	soiling, toxic	volcanoes	natural	mouth of volcano	none	none	solid & gas
DUST	soiling	arid areas	natural	arid area	agricultural practices	none	solid
POLLEN	irritation, discomfort	plants	natural	plant	weed control	regulations	solid
RADIOLOGICAL CONTAMINANTS	toxic	nuclear energy sources	X-ray equipment, testing, fallout	X-ray equipment nuclear energy uses	accepted practices	"	radiation
SMOG	irritation discomfort	vehicles exhaust	chemical reaction of exhaust with sunlight	atmosphere	blowby & exhaust devices	"	gas
ODORS	noxious discomfort	vehicles, industry, incinerators dumps, etc.	decomposition, incomplete combustion, industrial processes, etc.	vehicle, industry, incinerator, dump, etc.	masking, counteraction, process control & design	"	gas

Chapter XXXI

Hospital and Nursing Home Sanitation

There are many features about hospital and nursing home structure, function, and operation which demand similar and even the same environmental hygiene requirements, but there are also particular features which are quite different, demanding different requirements. The most significant similarities are:

1. The residents of both are incapacitated to varying degrees.

2. Medical and nursing services are required routinely for the residents of both.

3. Fire hazards are particularly dangerous to the residents of both.

4. Accidents, in general, have similar etiologies in both.

The most significant differences are:

1. The ages of the residents are quite different in each.

2. The state of acuteness of the illnesses in hospitals is quite different from the chronicity of the illnesses and infirmities in nursing homes.

3. Activities relating to operating rooms, emergency clinics, and complex therapeutic measures in patients rooms of hospitals differ quite strikingly from the more simple maintenance therapy and rehabilitation activities in nursing homes.

4. The complexity of equipment in hospitals increases the problems of cross-infection and accidental explosions.

5. The problems of sterilization, disinfection, and air-borne infection are much more critical in hospitals than in nursing homes.

6. Food services are more complicated in hospitals than in nursing homes due to the differences in methods of distributing food.

7. The handling of laundry poses a more exacting problem in hospitals than in nursing homes.

8. Hospital pharmacy service is a much greater operation than in a nursing home.

The sanitarian who understands well the sanitation requirements of both hospitals and nursing homes will better appreciate and be more alert to the sanitary needs of either, and be more adept in solving their environmental hygiene problems.

Hospital Sanitation

The new concept of the hospital sanitarian is to center the responsibility for overall sanitation in an individual who can develop, administer, and operate a complete sanitation program. The Hospital Housekeeping Officer, or Environmental Sanitation Officer, is becoming the pattern. This specialist has knowledge of engineering principles, of chemistry, of bacteriology, of hospital aseptic techniques, and of specific technical skills as applied to new and improved operational sanitation methods applicable to the hospital environment.

The sanitarian is an important member of the Hospital Infection Committee. It is the responsibility of the sanitarian to determine those methods and procedures which will provide an environment that is conducive to the best medical and surgical treatment. He participates in those cooperative scientific studies which involve housekeeping functions, along with the

several professional individuals concerned. As new techniques and procedures are developed as a part of research projects, he is responsible for such tests or parts of tests which involve sanitation functions.

Although at the present time the majority of the control measures are directed towards the prevention of infection by the so-called hospital strains of Staphylococcus, these same control efforts will result in a general improvement of the total hospital environment and thus prevent cross-infections by many infectious organisms such as:

1. Streptococci which cause puerperal sepsis, endocarditis, septic sore throat, scarlet fever.
2. Coliforms and other enteric organisms which can cause epidemics of dysentery in hospitals.

3. Mycobacterium tuberculosis, which still must be controlled in the hospital.

4. Clostridium tetani and Clostridium welchii which are still being incriminated in hospital cross-infections.

5. Hepatitis virus which is a constant threat in hospitals due to its resistance to most germicides but not to high heat under pressure.

6. Pseudomonas aeruginosa which is often found in the hospital environment, and is known to cause infection.

7. Food-borne pathogens which are always a possible threat unless good food sanitation principles be followed.

8. The fungus, Candida albicans, which is beginning to receive attention as a possible cause of infection.

9. Hospital strains of Staphylococci which, although last in this list, are probably the most important at the present time.

The ultimate goal is clear and undisputable, i.e., the hospital must not do the patient any harm. This goal, as desirable as it is, will always be very difficult to attain for several reasons. Firstly, because the hospital is a "collection depot" for all varieties of illnesses, and secondly, it is populated with very susceptible hosts, such as the very young, the elderly, and those debilitated by disease. These susceptible patients may be infected by low concentrations of organisms which would have little or no effect on normal populations.

The basic principles of hospital sanitation are no different from the basic principles of sanitation in general. A difference, however, does occur in the areas of emphasis in certain techniques that must be applied due to the special categories of population for which hospitals operate, and the specialized procedures that must be applied for this population.

The Building

The condition of the buildings must be checked relative to general upkeep and condition. Equipment must be clean and in good repair for the safety and well-being of the patients. The buildings should reflect good housekeeping and should be free of insects and rodents and when necessary dust control measures should be employed.

Separate staff facilities must be provided for surgical, delivery, and nursery department personnel. Such facilities should include dressing rooms with toilet and lavatory facilities including soap and towels.

Corridors and doors should be of adequate width to provide for movement of patients and standard size wheel stretchers. All doors to the outside must open outward and be provided with self-closing devices. All stairways, ramps, and elevators must be provided with nonskid floor surfaces and must have handrails on both sides.

Noise: Because the easily maintained surfaces of floors, walls, and ceilings do not absorb the sound, the average hospital is like a large echoing chamber. Noise spreads out, bouncing off hard, noise-reflecting surfaces, down corridors from one room to the next. Actually, plaster walls, tile floors, and concrete reflect almost all of the sound waves striking them. There is much that can be done in this area to minimize the patients' discomfort.

Housekeeping: The age of the hospital, its internal design, and the finishes used can greatly influence the ease or difficulty of the housekeeping chore. Floors should be smooth, washable, non-absorbent, and free of cracks and crevices to prevent harborages for filth and organisms. All sharp corners which are difficult to clean should be eliminated. The angle between walls and floor should be coved for ease of maintenance. Walls should have a smooth finish capable of withstanding repeated washing. Dust collecting ledges should be eliminated or kept to a minimum. Ceilings may be acoustically treated for noise control; however, the surface must be washable.

Floor and Wall Cleaning: The cleaning of floors, walls, and ceilings must be satisfactory from a bacteriological as well as an esthetic point of view. Wet cleaning methods, proper cleaning of mops, and the use of good germicides are important. Mechanical cleaning equipment which tends to raise and redistribute dust and bacteria should be avoided. Mechanical floor polishers and bag type vacuum cleaners can disseminate dust and organisms. Wet type vacuum cleaners, equipped with filters which can be sanitized, are preferred. If wet mops be used, the mop heads should be laundered daily. A greater degree of safety may be attained by having individual mops for each hospital area, such as the operating room, delivery room, nursery, etc. Only damp dusting methods should be used, preferably with a cloth dampened with a good germicide. Mops must not be shaken either indoors or out. Cloths should be immersed over night in a detergent germicide, prior to washing them. Floor cleaning in patients' rooms should be done in the morning as soon as bed making is completed. In isolation units, nurseries, delivery rooms and operating rooms, floors are sanitized daily utilizing the wet pick-up technic.

On general wards, treatment of the floors once a week is enough. In an isolation unit or on a ward where sepsis is present, disinfection should be assured daily. Walls are not particularly important unless spattered with sputum, wound exudate, or blood. Ordinary good housekeeping routines are adequate until the patient is discharged when terminal disinfections should be carried out. This is best done with the spray technic so that an effective concentration of the active agent is applied directly to the walls.

Carpets collect dust, blood, excreta, vomitus and spillage of all kinds. If a carpet must be dealt with in an isolation unit, it should be flooded with a detergent germicide and vacuumed to remove as much excess solution as possible. Since oil may damage the flooring material and is not in itself a disinfectant, it is generally agreed that oiling of floors is unnecessary. There are more effective methods of dust suppression.

For disinfecting operating room floors or floors especially contaminated, the following wet pick-up vacuum cleaner technique is used most effectively: 1. Remove all furniture from room. 2. Pick up dry trash with vacuum cleaner. 3. Wipe shelves, mouldings, radiator tops, window sills, etc. with cloth dampened in solution of quaternary ammonium compound or synthetic phenolic. 4. Make up 10 liters of detergent germicide using a quaternary, iodophor, or synthetic phenolic. 5. Spill one liter of solution on the most heavily contaminated area of floor, usually in the center of operating room or, otherwise in the area around the bed. 6. Using a clean, laundered mop head, vigorously mop this area. 7. Spill the remainder of solution on same spot and spread with mop to periphery, using scrubbing motion where necessary to completely dissolve blood or pus and to pick up fixed soil. 8. Remove excess solution from floor with a wet pick-up vacuum; begin at the door and circle the room, working in gradually toward the center. Retreat from the room to the door can then be made over dried floor. 9. Return castored furniture to room through a puddle of freshly spilled germicide at the door. 10. Rinse mop head in flushing rim service sink. 11. Make up fresh bucket of solution. 12. Proceed to next room. 13. At end of day's cleaning, discard mop head for laundering. Rinse bucket in service sink. Invert for drying. By the time approximately 10 liters of solution

have been spread over the floor, and any one area is cleansed, there has been exposure for at least three minutes, which is sufficient for the necessary antibacterial action.

If this procedure be followed for nine or ten days, the bacterial count will drop from about 500 per square centimeter to 0 or 1. This is the goal of daily sanitation of the floor. The following criteria for floor cleanliness should be considered worth observing: Operating room floors: 0 to 5 organisms per sq. cm., ward floors: 5 to 10 organisms per sq. cm.

The procedure for determining the bacterial count of a floor:

1. Place a sterile template on the floor.

2. Moisten sterile swab in Butterfield's buffer solution.*

3. Scrub area isolated by opening in template for 30 seconds with swab.

4. Return swab to buffer. Break off applicator. Aseptically replace cotton stopper. Gently rotate tube.

5. Promptly transfer 1 ml. aliquot portions of buffer culture to agar pour plates.

*Butterfield's solution is made up as follows: Dissolve 34.0 gms. potassium dihydrogen phosphate (KH_2PO_4) in 500 ml. distilled water; adjust pH 7.2 with 1M NaOH and make up to 1 liter with distilled water. Add 1.25 ml. of this stock phosphate buffer solution to 1 liter distilled water. Sterilize 5 ml. quantities in cotton-stoppered test tubes.

Septic cases should not be restricted to specific operating rooms. The concept of setting one room aside for septic cases was abandoned years ago. No distinction is made between cases and they are scheduled indiscriminately to suit surgeon and hospital needs as long as a standard clean-up technic be used after every case.

Since contamination during surgery is confined to instruments, linen, and floor, and since the sterilizing room is an area apart from the surgical field, it is not considered contaminated. Germicidal shoe baths at the entrance to every operating room prevent the tracking of bacteria from operating rooms to corridors, sterilizing rooms, and other hospital areas. This is composed of a door mat of polystyrene or other suitable plastic which is immersed in a shallow tray containing long acting detergent germicide such as a synthetic phenolic or quaternary.

Cleaning up after operation is not done in the sterilizing room. A truck containing all the equipment necessary for disposing of linen, instrument, and supplies is wheeled into the operating room at the end of the case. Soiled instruments are placed in buckets which are placed directly in the sterilizer. Soiled linen is placed in a marked laundry bag for treatment in the laundry. Unused, clean, heat-stable supplies are placed in another bag for terminal sterilization in the supply room. Solutions for cleaning the operating table and instrument table are dispensed from the truck. The contents of the suction bottle are emptied into a flushing rim sink and the bottle is cleansed and terminally sterilized. The floor is mopped with detergent germicide as described above and the room is ready for the next case. What are the best ways of bringing patients from the wards to the operating rooms? Some are brought on litters and transferred to the operating table in the recovery room; others are brought on litters which remain in the recovery room,later to be recovery beds postoperatively; others come in their own beds and are returned to their own beds postoperatively.

The important feature in any case is to avoid taking stretchers or beds from the wards directly into the operating area itself. This is not a good technic. Patients must be transferred to the operating table in an interchange area so that dust, lint, debris, and bacteria are not tracked in to the operating room on casters and bedding.

Although almost universally accepted for their surface protective and esthetic qualities, floor waxes and polishes offer little toward combating cross-infection. The degree of effective-

ness may be equivalent at best to that of disinfectant residues remaining on surfaces as a result of routine daily treatment. Thus, such products alone should not be depended upon for adequate disinfection. Improperly employed, floor waxes may even become a reservoir for bacteria. To minimize this, the following precautions should be observed:

1. Before applying a wax, make sure the surface has been thoroughly cleansed, rinsed (preferably with a germicidal solution), and dried.

2. Apply wax in a thin layer; allow to dry and buff if desired.

3. Wet mop with a germicidal solution between waxings.

The floor is an important reservoir of infection in the hospital. Whether organisms are spit out, sneezed out, rubbed off from skin, brushed from clothing--whether they come from dressings, blood, or pus spilled on the floor, discarded plaster casts, or suture ends discarded to the floor--they all aggregate on the floor. Any activity mobilizes the dust and bacteria, and air-borne contamination results.

Floors in operating rooms need special consideration in addition to their cleanliness. Conductivity of the floors to prevent build up of static electricity must be maintained. This conductivity must be maintained at a resistance of between 25,000 ohms and 1,000,000 ohms-- a minimum of 25,000 ohms to prevent electric shock and a maximum of 1,000,000 ohms to prevent sparking and possible explosion. Tests should consist of readings at five or more locations, and the average of readings should be within the 25,000 to 1,000,000 ohm range, with no single value less than 10,000 ohms nor greater than 5,000,000 ohms. Such tests should be made monthly.

Bathrooms and Toilet Facilities

Adequate toilet facilities of the proper type must be provided. Water closets must be of the elongated bowl type with open front seats. Toilet rooms must be adequately ventilated. Hot and cold water must be provided at all lavatories, sinks, and similar fixtures.

In patients' bathrooms, a definite regimen of cleaning with a quick acting, non-odorous, non-irritating germicidal detergent should be established--twice a day in infected or key areas. Baths, showers, mats, and toilet seats should be similarly treated. Hand basins and other equipment used by bed-patients must be collected and sterilized after use, particularly in infected areas, unless they be for one patient's exclusive use. Showers could replace tubs wherever feasible, since they offer less possibility of contamination. It is advisable that patients not be required to clean a tub or sink before or after use, since greater control can be exercised if a definite cleaning schedule be followed by competent cleaning personnel.

Ventilation and Air Treatment: Attention should be paid to ventilation requirements. This includes heating and cooling. Heating systems must be of such type and maintained and operated in such a manner as to provide a comfortable temperature for patients and hospital personnel. Space heaters, if used, must be screened and vented to the outside.

In addition to the cross-infection problem, the comfort of the patient must be considered. Proper temperature, air movement, and humidity have physiological importance to the patient. Certain areas of the hospital, i.e., operating rooms, nurseries, laboratories, laundries, etc., must receive special consideration due to the activities carried on in such areas.

Operating room ventilation should be maintained at slight positive pressure in relationship to the rest of the hospital. Until the importance of the methods and patterns of supply and exhaust have been proven, it will probably be best to avoid expensive renovations of the ventilation system. However, regular inspection and cleaning of air intake sources, screens, and filters should be carried out. It is also generally agreed that recirculated air from other parts of the hospital should not be supplied to "high risk" areas such as operating rooms, nurseries and wound treatment rooms.

The following chart was compiled by Gohr and summarizes recommendations of design criteria for ventilation systems in hospitals:

Area	Pressure	Air Changes/Hr.	Temperature and Relative Humidity	Recirculation	Miscellaneous
Bact. Lab.	Neg.	10		Gen. Lab. 75% if filtered	Velocities less than 25 fpm at working level
Virus or Inf. Lab. (T.B.)	Neg.	10		No	Local exhaust. Exhaust air treated 600°F.
Autopsy room.	Neg.	10		No	
Animal Quarters	Neg.	10	75-80° F. 40-50% R.H.	No	Air diffusion to avoid drafts
Radiology		3	Up to 80°F. R.H. 40-50%		
Dark Room	Neg.	8		No	
Nurseries, nursery examination rooms & work areas	Pos.	3	75°F., R.H. 50% for full term nurseries 80°F., R.H.55-60% for premature nurseries	Yes	Velocities less than 25 fpm at fl. level. No recirculation of air to nurseries from other areas
Patient rooms		1½	75°F., RH.45-50%	Yes, if filtered	
Isolation Rooms	Neg.	3		No	
Treatment Areas		4			Spec. requirements for type of area
Operating Rooms	Pos.	10	72-76°F.,R.H. 55% to reduce hazard of static spark	No	100% filtered outdoor air supply. Exhaust air near floor to remove heavy anesthetic gases and create piston effect to settle dust.
Recovery Rooms		3	72-76°F.,R.H.55%	Yes, if filtered	
Anesthesia Storage		2			
Central Sterilizing and Supply					Local exhaust for heat and steam
Delivery Room		Same as operating rooms			
Kitchens		10		No	Local exhaust over cook and steam equipment
Dishwashing		10			Local exhaust over dishwasher
Laundry	Air movement Clean to Dirty			No	Local exhaust over work ironer
Storage, Soiled Linen	Neg.	8		No	Enclosed area Separate from main laundry
Sorting Room	Neg.	8			

Air treatment has received much attention, and a great deal of research has been done on the use of various aerosols, such as glycerine, resorcinol and tri-ethylene glycol, on the use of electron-precipitation filters, and on the use of installation of ultra-violet lamps. Although very successful results have been reported by individual researchers, most of these control measures have their shortcomings in that they are only effective under ideal conditions which are very difficult to achieve in practice. The drawbacks in the use of ultra-violet light are (1) the need for the direct impingement of the ultra-violet light upon the bacteria; (2) personnel in the exposure zone must be properly protected from skin and eye exposure; (3) ozone which is produced is a poisonous gas; (4) ultra-violet lamps must be continuously checked to insure that they are operating efficiently; (5) the battery of lamps needed to irradiate even a small room would be too cumbersome for mobile operation.

Inspection and evaluation of an apparently well-functioning air conditioning system should take into consideration the following factors:

1. Air intake louvers should be located so that they are remote from sanitary vents and smoke stacks. They should be designed to discourage the nesting of pigeons and other birds. There must be no likelihood of occlusion by vines or vegetation.

2. Filters must fit frames tightly and must be clamped in place so that air cannot leak around the edges. Filters should be easily accessible for inspection and changing. Where electrostatic collectors are used for aseptic areas and in systems that recirculate air, it is best to install an automatic device to purge the plates with hot water and reapply periodically. It is estimated that a good filter will retain at least 80 per cent of atmospheric dust or its equivalent.

3. The humidifying plenum should be protected by an automatic system for dispensing the corrosion inhibitor and germicide. It should be grossly clean. The water should be clear. Both preheating and after-heating coils should be free of equipment such as motors, piping and wiring where dust and bacteria accumulate and cleaning is difficult. This is the chief criticism against the use of self-contained package units. An after-filter affords extra protection against contamination by droplets or flecks of slime that have dried on the refrigerating coils.

A well-functioning air conditioning system should change the air in a room ten to twelve times an hour; slight positive pressure should be maintained within the patient areas so that bacteria do not infiltrate from adjacent rooms or corridors.

Ideally, fresh air should be introduced from the top and escape the room through crevices underneath doors, or through louvers near the floor. In this way, air-borne bacteria in the room are continuously diluted and are displaced downwards and outwards by fresh air. The bacterial count in a clean room, occupied by masked individuals, is reduced some 98 percent by proper ventilation.

Humidification can also be accomplished by the use of steam injectors or by contact with hydroscopic solutions such as lithium chloride. The latter is self-disinfecting because the bacteria do not survive in such a salt solution of the hypertonicity used to control the amount of water vapor left in the air.

In isolation areas where bacteria must be confined, exhaust systems are used in place of positive pressure systems. Tempered make-up air and exhaust air are balanced so that air leaks into rather than out of the contaminated room to prevent the dissemination of bacteria throughout the building.

Exhaust fans are a reliable method of removing contaminated air from an isolation unit where natural ventilation of open doors and windows is relied upon. Provision must be made for make-up from an open window in the same room. Dilution of the organisms in the outdoor air by the fan can usually be relied upon to remove the hazard of cross contamination. If, however, the exhaust fan discharges into an airwell, hallway or directly into an adjacent window, cross contamination and further spread is likely.

A major source of cross contamination from isolation rooms is the dust and dirt shaken from mops through open windows. This dust often drifts through adjacent windows or is aspirated by ventilating fans or air conditioners and spread throughout the building.

The exhaust air from communicable disease units or from the hospital in general need not be given any special consideration or treatment. Dilution in the atmosphere is relied upon except for exhaust air from laboratory hoods which may contain highly virulent contamination; in such cases incineration or ultraviolet radiation should be used.

It can be determined whether ventilation in a room is under positive or negative pressure by closing all the doors to a room and searching for drafts about the edges of the door. These should flow outward from the room if there be positive pressure within the room. If the pressure be negative the air would, of course, flow into the room. A vapor trail from a piece of carbon dioxide ice can be used to demonstrate the direction of drafts.

The question frequently arises whether the operating and delivery rooms should have a separate ventilating unit. Currently, it is customary to provide separate plenum chambers for various areas in a hospital. Each plenum chamber will have its own source of clean air and a means of filtering and tempering the air -- either with steam coils or refrigerating coils. Centralized ventilating plants, however, can be reliable if properly monitored and maintained.

Exhausting air from an operating room through the sterilizing room is an economical way of ventilating the latter. It need present no bacteriologic hazard in a well managed suite where the air count is less than 4-5 organisms per cubic foot. Individual organisms suspended in the air seldom settle out. It is the dust-borne organism that causes difficulty. Where economics are unimportant, sterile air ideally should be used in all aseptic areas. Unfortunately, this can be prohibitively expensive and the compromise described is justifiable and safe.

The over-all sepsis problem from air is not much reduced by providing 100 per cent fresh air throughout a hospital instead of recirculating air. If housekeeping be poor, 100 per cent fresh air will do little to curb the infection rate. Even sterile air picks up dust and its bacteria as readily as unsterile air.

Can the average small hospital with a part-time bacteriologist do air cultures from the point of view of affording the expensive equipment and employing a highly trained person to operate it? The all-glass impinger is an inexpensive device for collecting the bacteria in samples of air. It is not difficult to use. Petri dishes can also be exposed to collect particles that settle out of the air. A fifteen-minute exposure of a Petri dish represents the number of particles settling out on one square foot per minute (rate of deposit). Volume air samplers collect the total number of bacteria in a given volume (bacterial density). Settling velocity is the quotient. A high settling velocity (greater than one) indicates dust-borne bacteria; a low velocity indicates droplet nuclei (less than 4 ft. per minute). Room air has a settling velocity of 1 to 2 feet per minute, indicating the preponderance of dust-borne organisms. Settling velocities can be used to differentiate air-borne from dust-borne contagion.

The following criteria for bacterial counts in the air should be seriously considered: Operating room -- 5 to 10 organisms per cubic foot; ward air -- 10 to 20 organisms per cubic foot.

Space and Storage: There must be sufficient amount of suitable storage space throughout the hospital for all supplies and equipment. This storage should be on shelves, away from foot traffic and not exposed to overhead contamination.

Adequate space is very important in a hospital not only for patient habitation, but also to provide for the many ancillary services which the patient requires during his stay in the hospital. Adequate space should be provided in out-patient clinics as well, not only for the comfort of the patient but for preventing such clinics from becoming a center for spread of disease. Adequate space will also contribute to higher quality medical service. Space must be provided to properly isolate patients with infectious or suspected infectious disease. Ward sizes have been gradually reduced until the four bed ward is about average, and new hospital construction

seems to favor double and single rooms.

The American Academy of Pediatrics has suggested certain criteria which may serve as a guide in evaluating overcrowding of the newborn. It recommends that nurseries contain no more than 12 infants and preferably only 8. It further recommends that each infant be allowed a minimum of 24 square feet and preferably 30 square feet. Space for isolation bassinets should be 40 square feet per bassinet. It further recommends one isolation bassinet in the isolation nursery for each 30 bassinets in the regular nursery.

The American Academy of Pediatrics recommends that partitions for creating individual bassinet cubicles not be used, since they only create cleaning difficulties and do not prevent cross-infections. On the other hand, Standard Plans for Nurseries for Newborn by the USPHS, recommends that the bassinets be separated by partitions, forming cubicles of sufficient size to enable a nurse to give bedside care conveniently to each infant. It would seem, however, that if the recommended floor space per infant were available, there would be little advantage in having partition separations. But, if cubicle curtains should be used, they should be treated with a germicidal rinse in the laundry as are all other linens. They should be changed weekly on non-septic units, and, when used to isolate an infectious patient, they should be changed every twenty-four hours.

Food and Drink Service: The basic sanitation principles for food service in hospitals are no different than those for any public eating establishment, but the standards of cleanliness and food service hygiene should be of the highest level due to the increased susceptibility of hospitalized patients, and the greater environmental threat of spread of pathogens in a hospital. Food service in hospitals does have some unique aspects in the application of principles. Food must often be transported some distance from the preparation location to the individual diner. This may be accomplished by heated carts or by tray and belt conveyors. In both instances the food must be protected against contamination while in transit. Temperature and time elements during transportation also must be considered. As required for all food service places:

a. There must be adequate facilities for the sanitary storage, preparation, and serving of food. (In hospitals, space and facilities must be available also for baby food formula materials, preparation, delivery, and serving.)

b. All food and drink must be purchased from an approved source.

c. All food, drink, and ice must be stored, handled and served in a sanitary manner in accordance with the state or local sanitary code.

d. All milk and cream must be pasteurized and be of a Grade "A" quality.

e. All readily perishable food or drink, including that furnished to patients by sources other than hospitals, must be kept at or below 50°F. except when being prepared or served.

f. All equipment and utensils used in the preparation and serving of food must be properly cleansed, sanitized, and stored.

g. No room used for food preparation may be used for sleeping purposes, and said preparation room must be free from overhead contamination.

h. Ice must be handled and stored in such a manner to eliminate contamination.

Chipped ice melts quickly and the water that collects may support bacterial growth. The ice maker must be inspected at regular intervals. The entire water system and the porcelain-protected storage compartments should be washed and rinsed regularly with a sanitizing detergent. When ice storage compartments are located at stoop level, the ice maker must be mounted high enough off the floor to minimize contamination of doors and grilles with floor debris. There must be an adequate air break between the outlet drain and the waste pipe. Ice makers and ice cubes can be rendered germicidal by metering chlorine dioxide in the form of perchlorodoxane into the feed water. This germicide is odorless, tasteless, nontoxic, and noncorrosive.

Ice should be delivered to wards in plastic bags -- transferred from a central ice maker with a shovel or scoop kept in a solution of a quaternary ammonium compound and sanitized by heat daily. On the wards, ice cubes should be kept in the original bag stored in a refrigerated container and dispensed from the bag with tongs. The tongs should be similarly stored between use in a solution as above and heat sanitized daily.

Belt conveyors and tray elevators are comparatively new and have created some problems of sanitary maintenance. Trays do tip over and grossly soil the elevator shaft or belt and belt table. Belt washers have been designed and are in use, however, the problem of cleaning elevator shafts and belt tables needs continued improvement and investigation.

Special problems in food service are created by infectious disease of isolated patients. Food utensils and uneaten food should probably not be returned to the central kitchen area, but should be cared for in the individual room or ward. Many hospitals have met this problem by the use of disposable paper service which can be disposed of along with other infectious waste.

Water and Plumbing: All hospitals must be provided with an adequate supply of safe and potable water. Water must be from an approved public water supply or a private water supply properly constructed and maintained and approved. Bacterial samples collected semi-annually must show absence of bacteriological contamination.

Once the water enters the plumbing system within the hospital, the protection of its potability becomes the responsibility of the hospital. Plumbing must be in strict accordance with the requirements of the State Sanitary Code and applicable local ordinances. The system must be free of cross connections and back-siphonage hazards.

a. Drinking fountains, when provided, must be of an approved angle jet type.

b. Approved type equipment must be provided for cleaning and sterilizing bedpans.

Unlike the hotel, office building, or restaurant, the hospital has, in addition to the normal liquid wastes, materials which are deposited into the sewerage system that may be highly pathogenic. Thus, any condition which could allow a cross-connection or back-siphonage from the sewerage system to the water system is doubly dangerous. In addition to the normal plumbing fixtures such as toilets, lavatories, and sinks, hospitals have many specialized fixtures such as: sitz baths, bedpan hoppers, autopsy tables and sinks, hydro-therapy units, etc., which require special protection.

Since vacuums can and do occur in water lines, it is essential that the water inlets to the fixture terminate a safe distance above the highest possible water level in the fixture. If this arrangement be not possible, backflow preventers must be installed. It must be remembered that backflow preventers are mechanical devices which are subject to failure, and thus must be occasionally tested.

Sterilizers, dishwashing machines, refrigerators, and food preparation equipment should not be directly connected to the building sewerage system because of the possibility of a stoppage in the drain line resulting in a backing up of the sewage into the fixture. Such equipment should have indirect waste connections through an air gap.

Another frequently overlooked plumbing fixture is the humble floor drain. Often the drain is installed in anticipation of a wet cleaning method, however usually only a damp mop cleaning method is used, which means water is seldom if ever added to the drain. Thus the water in the trap evaporates and allows sewer gas to enter the premises. If floor drains be not used they can be sealed with a gasketed cover plate. Often drains are installed in toilet rooms as a precautionary measure in case of overflow of any of the fixtures. Unless these floors be washed with enough water to add water to the drain tap routinely, it will be necessary for the custodial staff to periodically pour water down the drain to replenish the water seal.

Waste Disposal: Garbage should be stored in metal covered containers not over 30 gallons in size and such wastes must be disposed of in a manner approved by the State or local Board of Health.

Contaminated dressings, surgical and obstetrical wastes must be handled in a sanitary manner and disposed of in an incinerator or by other approved method or methods.

Sewage must be disposed of in a manner so as not to create a health hazard or nuisance. Facilities must be in compliance with the requirements of the State or local Board of Health.

A hospital has considerable quantities of waste which must be disposed of daily. Studies have shown that approximately 6 1/2 to 9 pounds of waste per patient per day may be expected from hospitals. These wastes may be garbage, paper and other combustibles, medical wastes, surgical and autopsy material, and non-combustibles such as bottles and cans. Much of this waste is non-infectious and can be handled, stored and disposed of by normal means. However, a certain amount of the waste material must be considered potentially infectious and must be handled by special methods.

Adequate handling, storage and disposal of hospital waste is important for three main reasons: 1. To prevent the spread of infection within the hospital to patients and personnel, and outside the hospital to members of the community. 2. To prevent the growth of rodent and insect populations. 3. To prevent the production of offensive odors and unsightly conditions which result from improper storage, inadequate waste container cleaning, and improper disposal practices. While the second and third of these reasons deserve their share of attention, we will be concerned here about wastes and their relationship to the spread of infection.

The handling and disposal of potentially infected wastes such as soiled dressings, sputum cups, nasal tissues, tongue blades and waste from clinic treatment areas is very important. Usually these wastes are placed in paper bags which line the normal waste containers. These bags are removed from the container and the tops carefully closed prior to being placed in a larger collection container. When the larger container is full, it is taken to the incinerator. Study has been made of the use of cardboard containers, where the entire container and its contents can be incinerated. It has been recommended that dressings should be autoclaved before disposing of them. If dressings be placed in a large can or bag carelessly, there is danger of them being transported all through the hospital, and frequently the bag breaks and dangerous bacteria are spread.

Note should be made of the necessity of providing washing facilities for all storage and collection containers, since these will invariably become soiled and contaminated in use. All col lection containers should be thoroughly washed and steam-sanitized after emptying.

There are hazards of careless use of refuse chutes in the hospital. The air within these chutes can be heavily contaminated, and due to improper seals on the loading doors, this air can be injected back into the hospital proper. It is recommended that chute design be such as will prevent the return of any chute air to the hospital. Judicious consideration should be given of materials which may be thrown down the chute. Routine autoclaving of all disposable infected materials before discarding them should be practiced.

There is some inclination not to use chutes because of the difficulty of maintaining them. Strict attention must be paid to the proper cleaning of waste containers and trucks,to proper procedure and technique on the part of collection personnel, and to proper clothing for protection of collection personnel.

Lighting and Wiring: (See chapter on lighting) Usable rooms and general areas of the hospitals must be lighted adequately by natural or artificial light to include rooms where food is prepared and handled. Adequate emergency lighting must be provided for surgery, delivery, and emergency rooms. Flash lights or battery operated lamps for emergency use must be available for hospital personnel and kept in operational condition.

Radiation: (See chapter on Radiation Hazards) All equipment providing a source of radiation must be adequately shielded so as to protect operators, patients, and staff members at all times.

Linens, Blankets and Laundry Procedures: The hospital must make provisions and be responsible for the proper handling, cleaning, sanitizing, and storage of linen and other washable goods. Dray carts must be handled in a way as not to transmit communicable disease from one section of the hospital to another and the carts must be properly sanitized. Some recommend that all linen from the operating room, delivery room, nurseries, and isolation wards be routinely autoclaved before being sent to the laundry. Although it has been shown that the normal laundering process (hot water wash, bleach and ironing) will eliminate the chance of survival of dangerous organisms, the autoclaving will prevent personnel from coming in contact with the infected linen prior to its processing. Others recommend elimination of the sterilization process in favor of collecting infected linen in specially marked bags. The linen is taken to the laundry and placed directly in the wash wheel without any pre-sorting.

Linen pick-up and delivery is critical in hospitals because of the danger of linen becoming contaminated by an undiagnosed case of infection. In many hospitals, the same linen cart is often used to transport both clean and dirty linen. Needless to say, such a practice reinfects the clean linen with numerous organisms. The linen cart containing dirty linen, if left uncovered, may allow aerial dispersion of bacteria into the rooms and corridors. The most expeditious method of handling soiled linen is through the use of individual self-closing, ropeless, impervious laundry bags for each area. These could be dropped down the linen chute or loaded into a linen cart. The bags should be impervious to bacteria, otherwise the hazards of linen chute contamination will result. A less favorable alternative, if these bags were not available, is to line the dirty linen cart with easily washable cloth. For instance, nylon linings that can be removed or replaced on the cart without difficulty are now available for the standard size linen cart.

Linen should not be sorted in the hospital because of the hazard of bacterial dissemination. If sorting be done prior to washing, laundry personnel should be instructed and supervised in safe methods of handling soiled linen. If linen from isolation wards were not autoclaved prior to washing, laundry sorting personnel should wear masks and rubber gloves, and be provided with clean uniforms daily. Some hospitals wash all linens prior to sorting. The following procedure for collecting linens appears reasonable:

1. The nurse or aid wheels the hamper stand to each bed. The hamper stand contains a self-closing laundry bag, 18 inches in diameter. One piece of linen is placed in the bag at a time. The laundry bag should have at least a 6 inch overlap over the conveyor on which it is hung and should never be more than two-thirds full before being tightly closed.

2. The bag is sent to the sorting room by chute or truck. (If no pre-sort be used, first the linen in the bag, and then the bag itself is dumped into the washer.)

3. Sorting is done by trained personnel wearing clean uniforms, masks and gloves.

4. The laundry bags are washed folded and returned to their proper stations.

The following is a satisfactory premarking system for identification of linen bags used for collecting linens from various areas of the hospital:

All red: Isolation -- no pre-sort (bag is pulled back with hands covered by flap and pushed into wash wheel by fists; bag is washed at the same time.)

Black band: Diaper--no pre-sort.

Yellow band: Nursery and infant linen -- no pre-sort.

Green band: Operating room -- no pre-sort.

Red band: Delivery room -- no pre-sort.

Plain white: General linen -- pre-sorted.

Plain blue: Dietary linen -- no pre-sort.

Striped blue and white: Rags -- no pre-sort.

The following procedures for handling linens are recommended:

1. Remove linen from the bed with minimum of shaking.
2. Loose linens are carried to hamper and bag.
3. Do not drop linen loose on floor or down linen chute.
4. Use small containers for linen whenever possible.
5. Provide a clean area for sorting linens.
6. Eliminate sorting wherever possible.
7. Eliminate all unnecessary shaking out of linen by sorting staff.
8. For additional sterility precaution, pretreat linen with germicidal solution.
9. Keep linen clean after laundering -- keep away from dirty linen.

Blankets: Perhaps the most controversial area in the whole cross-infection problem is the matter of blankets. These have long been suspected of transmitting organisms either directly or via aerial dispersion. Blankets are famous for retaining large numbers of bacteria and for distributing them in lint.

Because wool blankets cannot be washed at high temperature (in excess of 160°F.) without causing "felting", they often retain large numbers of viable organisms. Some disinfectant rinses have been tried and have given favorable results, such as phenolics and iodophors. Woolen blankets can be disinfected in ethylene oxide sterilizers.

Although treatment with temperatures over 212°F. would give best results, blankets in use in many hospitals cannot withstand this treatment. However, it was found that turkish toweling, a special cotton weave, and Terylene (a synthetic polyester fibre) can be treated in this manner. It should be kept in mind that cotton is more flammable than wool, and Terylene more easily causes static electric sparking.

Of major importance is the cleansing of blankets after individual patient use. Every patient should have clean, freshly-laundered linens and blankets, and long term patients should have blankets every two or three weeks.

Cotton blankets, routinely used in the operating room because of the hazard of accumulated static electricity in woolen blankets, should come directly from the laundry to the surgery. With an efficient laundering system, these blankets are sanitary and safe for use. The practice of supplying each patient upon admission with a clean blanket wrapped in a polyethylene bag has been used. While the cost of the bag is 2 to 3 cents apiece, the favorable publicity is immeasurable.

Pillows, Mattresses, and Furniture: Pillows from infected patients should be autoclaved, or if laundry be equipped with the machine required, they should be laundered with treatment of feathers by live steam. Some hospitals have tried covering their pillows and mattresses with a plastic covering, but have reported that patients complain of the noise caused by movement on the plastic.

After the patient has been discharged, several techniques for handling mattresses are possible. First in order of convenience and safety is use of the ethylene oxide sterilizer which both deodorizes and sterilizes the mattress. Lacking such equipment, the protective plastic barrier

used as a mattress cover can be terminally disinfected. The covers are wiped clean with a germicide. Muslin covers can be laundered. Even vacuuming of a used mattress provides a measure of safety. Vigorous sweeping with a whisk is so much a part of nursing-arts tradition, however, should be discontinued because of the stirred up dust which is either inhaled or settles out on clothing and floor. The mattress may also be sprayed with a synthetic phenolic or a textile lubricant to achieve at least some degree of disinfection on the bed. The use of large ethylene oxide sterilizers would make it possible to sterilize such bulky items as pillows and mattresses.

Transferring furniture from a contaminated unit to an ethylene oxide sterilizer or to a steam cleaning facility leaves a path of infectious material. But wiping the furniture with a detergent germicide before hand at least eliminates the loose dust hazard. Mattresses should be put into a polyethylene bag when transported for disinfection. The bag accompanies the mattress into the sterilizer and serves as a wrapper on removal. The polyethylene is, of course, permeable and nonreactive to ethylene oxide, but would be disintegrated by steam. The necessity of cleansing linen items will undoubtedly be with us for a long time. On the other hand, perhaps the laundry of tomorrow may be an incinerator.

Studies are being made at the present time of potential use of disposable paper-base clothing and linens. Under trial are such items as bed linens, surgeons and nurses caps, gowns, jackets, trousers, floor uniforms and examination gowns, dental and patient bibs, and masks.

Laundries: Undoubtedly laundries should receive more consideration in regard to maintenance and design. Too often, laundry operations are placed in a neglected area of the hospital with little regard to ventilation, lighting or maintenance. Since clean, bacterial-free linens are recognized as an important part of hospital sanitation, then proper flow of linens through the laundry (from "dirty" towards "clean" areas), proper ventilation (from "clean" toward "dirty" areas), suitable separate sorting areas, more attention to removal of dust and lint, better wrapping and handling, cleaner storage and delivery, etc. should result.

Laundry chutes must be disinfected regularly. To do this rather simply, a 5 gallon garden spray tank is fitted with a pressure hose of sufficient length to reach the distance of two building floors (about 20 feet). A cone spray nozzle is fitted to the end of the hose. The tank is filled with a germicide such as a noncorrosive orthophenolic in a dilution of 2 per cent, then the inside of the chute door and entry to the chute is sprayed until perceptibly wet.

Aseptic Technique: There are certain basic aseptic techniques, which, although accepted and recognized as primary considerations in preventing the spread of infection, are often performed in such a haphazard manner as to negate their effectiveness. The concern about the antibiotic resistant bacteria may often conceal the real problem at hand resulting from the relaxation of aseptic and antiseptic precautions in the hospital, such as handwashing, gowning, masking, sterilization, disinfection, etc.

Handwashing: Handwashing is possibly the most important single control measure in the prevention of cross-infection. Hands should be scrubbed immediately preceding entrance to an isolation unit, and thoroughly washed before any patient care activity and again after care of each patient in the unit. It might be important to point out that many of the hospital personnel should review the proper technique of thorough hand washing.

A suitable procedure is given in the APHA Guide for the Prevention and Control of Infections in Hospitals, as follows:

1. Standing well away from the sink, turn on the water to temperature suitable to hands.

2. Moisten hands and apply a heavy lather of soap covering well beyond the area contaminated. Pay particular attention to the areas between the fingers and under the nails (toothpicks may provide for cleaning under the nails).

3. Use friction, one hand upon the other.

4. Rinse thoroughly under running water, allowing water to flow from above toward the finger tops.

5. Repeat steps 2 through 4.

6. Dry hands thoroughly. (Scrub time required: approximately 90 seconds.)

Since conveniently located handwashing facilities make personnel more conscious of the need for frequent hand washing, it has long been standard practice to require handwashing facilities in food preparation areas of hospitals. A large circular wash sink in the center of the nursery would remind doctors and nurses that aseptic technique depends on hand washing.

Sinks should have knee or foot controls and a mechanical soap dispenser. Surgeons scrub sinks have long been equipped with arm or wrist blades for opening and closing faucets. If the water supply be controlled by hand faucets, it is desirable that the faucets be turned off with the paper towels used for drying the hands.

Much use has been made of hexachlorophene soaps which have proven highly effective in reducing the bacterial count on hands. Alchohol or germicidal rinses are often used in nurseries and isolation areas as an additional precautionary measure.

Gowning: There is revived interest in suitable gowning for operating rooms, nurseries, and isolation wards. It is again fairly well accepted (in theory at least) that all persons in the operating room be required to wear operating room attire. A gown and mask should be worn by all persons who enter a nursery or other isolated area for short intervals. It is suggested, however, that for personnel whose primary duty is within the nursery or other isolated areas, the gown and mask could be omitted.

Where reliable personnel are well trained in the details of isolation technic, a single gown, kept outside of the patient's room, is acceptable. Lacking such training and high standards of efficiency, it is safer to supply a stock of gowns so that a fresh gown be worn for each contact with the patient.

The availability of gowns is only half of the answer, however. There must be adequate collection facilities for used gowns. Too often, a worn gown is tossed haphazardly at an inadequate bucket or left draped over a scrub sink. This break can negate the whole program of isolatiion technic. In an open ward isolation unit where several patients are cared for, the use of a single gown is not safe. There would be a great likelihood of superimposing infection from patient to patient with this technic.

Masks: Much attention has been been given to the use of masks in operating rooms, nurseries, and isolation areas. The mask performs a two-fold purpose. It protects the patient from nasopharynx carriers of organisms, and also protects the wearer from organisms of the patient. It has been shown that quiet breathing without a mask results in less spread of organisms than with a mask. This is probably due to multiplication of bacteria on the mask even in a short period of time. It is for this reason that it is suggested that nursery personnel who stay in the nursery not wear masks.

Masks vary from hospital to hospital and it is not wise to categorically state that double masking is right for every situation. Certain features of masks and masking should be considered:

1. The average hospital mask quickly becomes a poor filtering device for many reasons related largely to the quality of material used in the mask. The highest efficiency rate attainable in one study was about 40%.

2. The filtering action of a mask is only one part of its action. It must also prevent the deflection of bacteria around the edges. Hence, the impervious cardboard mask with buttresses is relatively worthless since bacteria are merely allowed to escape into the air about the wearer's head instead of being trapped on the meshes of a filter.

3. Masks become heavily contaminated with oro-nasal discharges. These discharges dry and droplets and droplet nuclei entrain in the expired air. Masks should be changed every 30 minutes throughout the work day.

4. The nose and mouth must be covered and the mask tied snugly about the head.

5. Once removed, the mask should be discarded and not worn loosely about the neck.

6. Soiled masks should be handled by strings only and discarded directly into plainly marked containers for laundering without preliminary handling.

7. Sterilization after laundering eliminates the hazard of cross contamination between users and from handlers in the laundry.

8. The organisms in a patient's nosopharynx may be as dangerous as any in the hospital. During a procedure performed under local anesthesia, the patient should wear a mask. When inhalation anesthesia is used, the organisms in a patient's expired air are confined to the anesthesia apparatus. When a proper barrier is erected between the anesthesia stage and the operative field, the few bacteria freed during intubation of the patient have little significance.

9. Masks with impervious inserts are poor filters and bacteria are simply deflected around the edges. The bacteriology of this type of mask is not nearly as good as that of an ordinary mask made of 6 layers of 42 x 42 gauze or 4 layers of 50 x 56 muslin. Double masking can be made equally ineffective if the masks are poorly made. However, because masks vary from hospital to hospital, it is necessary to know the individual problem before categorically condemning any one technic.

At the time the mask is changed, the old mask should be discarded into a proper container, the hands of the wearer thoroughly washed, and the new mask donned. Consideration is now being given to wearing of masks by doctors, nurses, and patients while septic dressings are being changed. Most hospitals now autoclave their masks so as to get them as sterile as possible before use. Although normal washing will produce masks of good bacteriological quality, the subsequent folding process, handling, etc., might cause recontamination.

Sterilization and Disinfection: There is no doubt that autoclaving is the method of choice for sterilizing all materials not damaged by this procedure. However, chemical disinfection can play an important role in housekeeping procedures and in treating bulky material or delicate instruments which cannot be steam sterilized. It is probably safe to say that no chemical disinfectant presently available can qualify as the "ideal" disinfectant. Furthermore, it is unreasonable to expect the same disinfectant solution to be entirely satisfactory for such diverse purposes as floor cleaning, decontamination of equipment contaminated with tubercle bacilli, and the sterilization of instruments. Thus the disinfectant must be selected and tested for its intended use.

When choosing sanitizing agents for general hospital cleaning, certain features should be considered:

1. Is there a residual antibacterial film formed?

2. Is it effective against a wide range of organisms?

3. Is it injurious to the surfaces to be cleaned?

4. Is it nontoxic, nonirritating, nonstaining, and has it a minimal amount of odor?

5. Is it compatible with soaps, detergents and all water supplies used in the hospital?

6. Is it inexpensive enough so the hospital could be literally bathed in it, if necessary?

Sterilization means the complete absence or destruction of all forms of microorganisms. Much is left to be desired when it comes to true sterilization by chemicals, since few are effective sporicides even after long periods of exposure. Heat is readily recognized as the most reliable, easily controlled sterilizing agent. Microorganisms cannot survive ten minutes direct exposure to saturated steam at 121°C. (249.8°F.) which is attained under ideal conditions at sea level with 15 pounds pressure in a steam sterilizer or autoclave, or 121°C. of saturated steam for 15 minutes under sea-level atmospheric pressure. Vacuum is not a factor in the process of sterilization.

Steam sterilization as normally conducted in an autoclave is the product of heat plus moisture, in which the moisture factor plays an exceedingly important part. Steam heats mainly through the transfer of its heat of vaporization as it condenses upon surfaces. With porous materials, such as surgical dressings, the steam leaves a film of moisture upon the outer layer and then penetrates to successively deeper layers, leaving a film of moisture on each as they are heated. Since all steam sterilization is based upon direct steam contact, it follows that the same process of condensation and heating applies to instruments, utensils, and other articles undergoing surface sterilization. With such impervious materials, there is no permeation with steam through the metal, the object being only to heat and sterilize the surface. In this case, the cold metal condenses the steam until the article is heated to the temperature of the steam. Because of this rapid heating effect, such instrument surfaces require less time for sterilization than is required for fabrics which require penetration of steam prior to heating.

The following factors have been found to be the most common cause of sterilization failure:

1. Failure to exhaust entrapped air so that the desired exposure to hot, moist steam is not attained.

2. Improper packaging and wrapping of supplies with no regard to size or density of individual packs.

3. Improper loading of the sterilizer so as to prevent free circulation of the steam, and the formation of pockets where contaminated materials are protected from contact with steam.

4. Reliance on an incorrect pressure gauge as an indicator of the temperature within the sterilizer. Failure to maintain 15-17 pounds pressure.

5. Use of relatively impervious material as wrapping which tends to exclude the steam.

6. Failure to time correctly the required period of exposure--usually due to ignorance or negligence on the part of the operator.

7. Attempts to sterilize materials which are impervious to steam, such as talcum powder and petrolatum.

The amount of pressure is not necessarily indicative of the temperature of the steam, especially if this pressure includes air trapped in the sterilizer. For example, saturated steam free from air at 15 pounds gauge pressure will result in a temperature of 121°C. But when no air is evacuated from the chamber and steam is admitted until the gauge registers 15 pounds, the maximum temperature attained after the steam and air have mixed may be only 100°C. Thus, it may be seen that the evacuation of air from the sterilizing chamber is a fundamental requirement for effective sterilization. The majority of steam sterilizers manufactured today employ the gravity process for the elimination of air from the chamber. This evacuation is accomplished as follows: Air is more dense than steam, and as steam enters the chamber, it fills the upper areas of the chamber and compresses the air towards the bottom. Since steam is admitted under pressure, air in the lower areas is forced out through the bottom outlet, through the thermometer case and air line trap, then on to the vertical pipe to atmosphere. (Note that the thermometer should be located in the discharge line.)

In preparing supplies for sterilization, operators should constantly bear in mind that safe performance demands complete permeation of every strand and fiber of the materials with

moisture and heat of the steam. If packs are too large and dense, inner portions may not be sterilized, or if sufficient time is allowed for sterilization of inner portions, outer portions may be oversterilized and damaged. Dressings, sheets, towels and gowns should be arranged in packs no larger than 12" x 12" x 20" for proper penetration and sterilization. Each succeeding layer in the pack should be placed crosswise to the previous layer to promote free circulation of steam through the mass. The outer wrapping must not retard the passage of steam and yet should act as a dust filter and resist tearing. The outer wrapping should not be drawn too tight, only tight enough to hold the material together.

Packs and materials must be arranged in the sterilizer on their sides to avoid interference with steam penetration. Jars and other containers should be placed on their sides or inverted with their covers loosely secured in place. An excellent rule to follow in sterilizing any dry material contained in a test tube or jar is to assumethecontainer is filled with water. The container should be placed in such a position that the imaginary water would drain out freely. Sterilization of liquids in test tubes, flasks, or bottles involves a different use of steam than is required for dry goods sterilization. In solution sterilization, the solution contains the necessary moisture which will absorb heat from the steam.

It must be remembered that it is not the pressure per se which sterilizes, but the steam under pressure. Dependence should not be placed upon a pressure gauge alone, but upon an accurate thermometer placed in the discharge line. The pressure gauge should serve only to indicate that the autoclave is operating within the limits of mechanical safety. With proper application of these requirements the following exposure periods should provide ample time for heat penetration and sterilization:

Surgical packs, normal size in proper covers	30 min.
Instruments in trays, with muslin covers	15 min.
Instruments, wrapped for storage	30 min.
Utensils in muslin covers	15 min.
Rubber gloves in muslin wrappers	20 min.
Treatment trays with muslin wrappers	30 min.
Dressing jars, loosely packed, on sides	30 min.
Glassware, empty, inverted	15 min.
Syringes, unassembled, in muslin or paper covers	30 min.
Sutures, silk, cotton, nylon	15 min.

The following exposures of aqueous solutions will afford a reasonable degree of safety in sterilization:

Container	Capacity	Exposure 121° C.
Erlenmeyer (Pyrex) flask	2000 ml	30-35 minutes
Erlenmeyer (Pyrex) flask	1000 ml	20-25 minutes
Erlenmeyer (Pyrex) flask	500 ml	17-22 minutes
Erlenmeyer (Pyrex) flask	200 ml	12-15 minutes
Erlenmeyer (Pyrex) flask	125 ml	12-14 minutes
Erlenmeyer (Pyrex) flask	50 ml	12-14 minutes
Fenwall (Pyrex) flask	2000 ml	40-45 minutes
Fenwall (Pyrex) flask	1000 ml	25-30 minutes
Fenwall (Pyrex) flask	500 ml	24-28 minutes
Square-Pack (Pyrex) flask	1000 ml	30-35 minutes
Serum Bottle (Pyrex)	9000 ml	50-55 minutes
Milk dilution bottle	100 ml	13-17 minutes
Test tubes	18X150 mm	12-14 minutes
Test tubes	32X100 mm	13-17 minutes
Test tubes	38X200 mm	15-20 minutes

Certain materials, such as powders and petrolatum, anhydrous oils, greases, etc., because of their physical characteristics, cannot be permeated by the moisture of steam and must be sterilized by other means.

Treatment of Special Equipment: It has been found that oxygen therapy equipment becomes more contaminated with pathogenic bacteria than had been anticipated. The following appears to be a suitable sterilization schedule for satisfactory results:

1. Water must be sterile. Should be discarded and replaced when the level falls.

2. Apparatus must be dry and not allowed in service for longer than one week.

3. Glass reservoirs should be inverted or covered. Must be cleaned each week with soap or detergent and a good disinfectant. Rubber washers should be inspected and replaced if defective due to cracks or frayed ends.

4. If suitable equipment be available, the metal top of the humidifier should be autoclaved after individual patient use.

5. Whenever possible, disposable tubing should be used.

6. Bacteriological spot checks should be run at regular intervals.

Positive pressure incubators and infant resuscitators should be sterilized between use. A separate pure air supply for each incubator is also recommended.

Anesthesia equipment, including masks, tubes, and bags must be suitably cleaned between patients. Anesthesia tubes and rebreathing bags should be cleaned prior to and immediately after use, with water and a liquid soap containing hexachlorophene.

All patients, especially infants and infected patients should be provided with individual thermometers. Upon discharge of the patient, the thermometer must be carefully disinfected. One method of sterilization is as follows:

1. Wipe the contaminated oral thermometer with a cotton ball moistened with a solution of equal parts of 95% ethyl alcohol and tincture of green soap. Wipe vigorously to remove sputum.

2. Rinse the soap off the thermometer with cold running water.

3. Store thermometer in a solution of 1/2 to 1% of iodine in 70% ethyl alcohol or 70% isopropyl alcohol.

This same method will satisfactorily treat rectal thermometers if a water soluble lubricant be used.

All bedside equipment needs attention. There is need for improved care in regard to the bedside water pitcher and the glass. These pitchers should not just have water added as necessary, but should be emptied and cleaned at least daily. Some hospitals are autoclaving water pitchers daily, while others are using disposable paper pitchers which can be discarded. The bacterial count of the water in the pitcher must not be higher than the bacterial count of the water being supplied to the hospital.

Terminating Patient Isolation: The patient can be removed from isolation when cultures of the disease process have become negative and when the infecting organism is no longer recoverable from the patient's bedding. A rigid program of skin hygiene is often needed to eliminate staphylococci or other pathogens from hair and desquamating epithelium.

Handling of Infected Personnel: The employment of personnel who are nasal carriers of an epidemic strain of staphylococci need not necessarily be terminated. It should be determined first whether the employee is a disseminating carrier or spreader. This is done by cultures of clothing, bedding, and underclothing. A disseminating spreader should not be working in a hospital. Once a spreader is discovered, a search must be made for possible pathology that may account for the pathogenic bacteria. If pathology be present, it should be corrected.

Intimate contacts should be investigated to find, if possible, the source of the inoculum. The hygiene of home and living quarters particularly should be investigated. If it be determined that there be no underlying pathology and no source of reinfection, hygienic and therapeutic measures may be helpful in eradicating the offending organism.

The immensity of such a control program emphasizes the need for a full-time health or infection officer within the hospital community.

Many states now write compensation laws for hospital acquired staphylococcal infections in the personnel. Since the trend is likely to continue, personnel policies should be devised to keep pace. Compensation will encourage prompt reporting of skin infections and dermatitis.

Personnel with overt staphylococcal disease or, for that matter, other conditions liable to spread pathogens, must be barred from the hospital until proven safe by bacteriologic examination. Skin infection will probably prove to be the predominant condition to be dealt with. Personal integrity in reporting obvious infection and skin disease will greatly simplify the process of detection. This will be facilitated by a just compensation system, the availability of aggressive therapy, effective educational and training programs, and sympathetic assistance in relocation in the event therapy is ineffective.

The second most prominent infected group that must be kept out of the hospital is that manifesting overt respiratory infections. Such people not only spread secondary invaders liberally from the nasopharynx but also shed heavily from skin, perineum, and clothing. Bacteriologic screening prior to return to work may help detect the spreader who must have therapy.

A training program in personal hygiene is essential for hospital personnel. The care of skin and hair, cleaning of clothing and bedding, and proper management of the home which has proved to be a source of reinfection are important.

Most of the disseminating carriers or spreaders will automatically disclose themselves under the policies described. The latent spreader will then have to be detected by culture of his person or living quarters.

Elimination of infection-causing staphylococci from a disseminating carrier is a challenging task. The elimination of the carrier may not be achieved for some carriers. The following approaches offer possibilities for success for individual spreaders:

1. Pathology that seeds staphylococci must be identified and treated. Nasopharyngeal or genito-urinary tract infections are often involved. Dermatitis, particularly of the scalp and perineum, is another prolific source of staphylococci.

2. A program of specific therapy must be used in conjunction with a rigid program of skin and hair hygiene to rid an individual of the offensive strain of staphylococcus.

3. Staphylococci in the individual's working environment, home, or consort must be investigated. Social distance is an important dimension in staphylococcal transmission.

4. A change of environment may permit a complete change in an individual's bacterial flora. On return to work, reinfection must be prevented. Assignment to a noninfective part of the hospital, wearing of masks, or the use of an effective nasal spray have been used as effective measures.

5. In desperate situations, toxoids and vaccines may be a last resort.

Control of Visitors: The relaxed and casual attitude of the public toward visiting patients in hospitals has created additional communicable disease hazards for the patient as well as adding emotional strain and fatigue to the patient. Also, the emergency of antibiotic resistant infections has increased hazards to the patient's uneventful recovery with the result that everyone around the patient must observe the strictest aseptic technic if the patient's safety is to be safeguarded. Therefore, since the safety of the patient devolves around everyone --

hospital, physician, nurse, relatives and friends -- the following mandatory restrictions should apply to all general hospitals:

1. Visiting Hours: Visiting hours must be limited to one hour during the day and one hour in the evening. The exact hours should be set by each hospital administration in such a way as not to interfere with the care of patients.

2. Number of Visitors: Not more than two persons may visit a patient at any one visiting period.

3. Visiting by Minors: No person under 16 years of age should visit a patient.

4. Conditions of Visit:

a. Visitors must limit their visits to only the patient they have come to see and must not fraternize with other patients.

b. Persons with colds or other recent infections must not visit a patient.

c. Visitors must not sit on a patient's bed or in any other way violate the principles of isolation.

d. Patients under special isolation must be visited from doorside only (not bedside).

e. Gifts should be disposable or should be washable.

The Hospital Physical Environment and Patient Safety

Hospital environmental sanitation problems are numerous and of great magnitude, and many of them are directly related to the patient's safety. Accident investigation is, in a sense, a post mortem. Every patient injury constitutes proof that some hazardous condition or unsafe practice, or both, has gone uncorrected. Practically every paragraph in this chapter is a discussion of some phase of accident prevention. This section, however, will serve as a resume and also to emphasize some aspects of accident control needing special consideration.

There are certain recognized procedures for locating hazards in the hospital. These are (1) periodic and complete inspection of all facilities, (2) analysis of activities, and (3) investigation of each accident. Facilities inspection is valuable chiefly in locating hazardous conditions and arrangements. Analysis of activities of employees is of value in determining safe procedures and setting standards that will promote patient safety. Experienced employees familiar with operating procedures of the hospital can often locate practices which may lead to patient injuries. The following are examples of types of accidents that can be avoided by taking advantage of known safety practices:

1. The collisions caused by hospital carts at corridor intersections can be eliminated by the use of mirrors at blind corners.

2. Free rolling carts frequently bump patients and employees because they are not equipped with a common mechanical device known as a dead man brake.

3. Patients have been injured or burned because of exposed steam radiators which could be protected by barrier guards.

4. Nurses and aids are burned by the spilling of hot liquids when they receive a shock from an electrically heated "Meal on Wheels Cart" on which the ground connection had not been maintained.

5. Nurses, maids, janitors, and laundry personnel are frequently jabbed by used syringe needles because they are placed in aprons, towels, and gauze. These injuries could be eliminated so easily by jabbing the used needle into a polyurethene sponge immediately following use. Used disposable needles can generally be replaced in their original container for safe disposal.

6. Maids and orderlies are cut by old razor blades, broken glass, and other sharp objects when emptying waste baskets in patients' rooms. This type of injury can be almost completely eliminated by the use of plastic liners for all waste and rubbish containers.

7. Cuts also result from broken glassware being replaced on trays or racks because a specially designated container for broken glass was not available.

8. Warped racks on kitchen ranges cause hot liquids to be spilled, and a roasting pan set temporarily on an oven door that drops too far can cause hot grease to spill on the cook's foot.

9. Sprained fingers and wrists, bumps, bruises, spilled medication, and damaged equipment are all caused by swinging doors not equipped with vision panels so a person or cart can be seen approaching from the other side.

10. Hospital wheel chairs and carts should be provided with seat belts to secure patients.

Falls: Falls are the predominant cause of hospital patient injuries, as well as in nursing homes. (Refer to the problem of accidents under Nursing Home Sanitation, since very much of the latter is applicable to the hospital.)

Housekeeping personnel should be instructed in safety measures, such as using non-skid wax; scrubbing and waxing one-half of the corridor at a time, so that there is always a dry passageway for traffic; posting warning signs at each end of an area where floor maintenance is being carried on; spiral taping electric cords with brightly colored tape so they can be easily seen.

The mechanical condition of stretchers should be checked frequently. The patient should be moved feet forward on a stretcher, and secured with safety straps when indicated. Special precautions should be taken at corridor intersections, on elevators, and on ramps.

Burns: Safety precautions should be instituted in the use of heat therapy equipment. Heating pads should be used only upon the written order of the attending physician, and with a signed release from the patient. Electric pads should be kept in good repair and discarded when they begin to show wear; pins or other sharp metal objects should not be allowed to come into contact with them, and they should be kept dry. Electric pads, hot water bottles, and steam inhalers should not be applied to unconscious, paralyzed, or sedated patients. The temperature in hot water bottles should never exceed 130°F. for adults and 120°F. for children.

The fire hazard of exhaust ducts serving hospital kitchen ranges and similar equipment may be reduced considerably by installation of filters of the proper type to catch the grease before it enters the ducts. Steel wool should not be installed at the inlet to the exhaust duct because grease-coated steel wool ignites readily and burns with an excessive shower of sparks.

Christmas trees which have stood in plain water retain resistance to ignition longer and remain green and flexible for a greater time than either dry trees or trees treated with flame-proofing chemicals. It is strongly recommended that, even though a flame-proofing solution has been applied, the Christmas tree also be kept in a tub or other container of plain water, additional water being added as needed to keep the bottom of the tree trunk immersed. A fire-proofing solution suited for treating Christmas trees, fabrics, and many other materials is one made up of nine ounces of borax and four ounces of boric acid added to one gallon of water. Trees, fabrics, and other materials to be treated should be well saturated with the solution and then allowed to air dry.

Explosions: Smoking should be prohibited in rooms where oxygen is being administered. The use of 95 percent alcohol as a substitute for water to humidify the oxygen tent is an unsafe practice, because the solution will evaporate and create an explosive gas mixture. Many of the small hospitals, due to lack of trained personnel to operate the oxygen equipment, may choose to rely on nasal catheter administration instead of the mask method. With the nasal catheter, improper humidification can be overcome by proper design and use of the humidifying equipment. Improper design and use of this equipment may result in bubbling drops of water into the tubing through the catheter, with ill effects to the patient.

Instead of the portable cylinders, some hospitals are supplied with a stationary supply of oxygen which is transported through pipes to the various areas of use. A few of the advantages

of piped oxygen are as follows: (1) The tank is eliminated from the patient's room. (2) An adequate uninterrupted supply is insured. (3) The gas is more quickly and conveniently available. (4) The hazard of spontaneous combustion, which may occur when the high-pressure tank contacts grease or oil, is eliminated. (5) The need for the pressure regulator at the patient's bedside is eliminated, since the gas is delivered to the room under reduced pressure.

In order to minimize the potential hazard from anesthesia explosion, all portable equipment in the hospital operating room should be equipped with specially developed conductive rubber casters. Static electric charges are discharged through these casters when they are in contact with the ground or suitable electrically conductive flooring. Face and breathing bag masks are required to be conductive, as are restraint straps. Tires on equipment must be conductive and the equipment must be electrically connected together to adequately drain off the static charge to the floor. Oil is injurious to rubber compounds and impairs the electrical conductivity of these casters.

Floors adjacent to the operating room should be covered with conductive materials to dissipate any static electricity which may be present on personnel or equipment before they enter the operating room. The use of floor sweeping compounds, floor waxes, and other floor treating materials may impair the conductive properties of the floor so they should not be used in these areas.

Electrically conductive footwear should be worn to dissipate the static electricity from personnel clothing to the conductive flooring. To determine that the conductivity of the footwear has not been impaired by floor waxes or other accidental causes, the electrical resistance should be measured each time they are worn. Foot powders should not be used because of their insulating properties.

The filling of small containers from a large container of ether presents a hazard which may not be fully appreciated, and unless adequate safeguards in the way of ample ventilation and complete removal of all sources of ignition are provided, a serious fire and explosion hazard would result.

Tne vapors of ether are about two and one-half times as heavy as air, so they will tend to settle and remain in low spots; and, will flow in a stream along a floor or down stairs and, if they reach a source of ignition, will propagate flame back to the source even for considerable distance. Ether is rated more hazardous than gasoline.

Power Failure: Hospitals should be equipped with an auxiliary source or sources of electric power that feed only such areas as the operating and delivery rooms, and possibly stairs and stair landings. This is usually an emergency battery system. Power failure to various electrically operated pieces of equipment that are vital to life, such as iron lungs, would result in harm to many patients. It would seem advisable and practical to lay these lines underground all the way from the nearest power substation. Also, it might well be possible for these lines to take off from separate feeder positions in the substation, which should greatly reduce the chance of both lines failing at the same time. In addition to failures of the primary electric power source, there is always the chance of power failures within the hospital. The best solution to such problems is to have a system whereby each failure will report itself instantly, giving its exact location, so that it can be repaired quickly.

Radiation: In a period of widespread expansion in the use of radiation for therapy and diagnostic procedures in hospitals, administrators must be ever alert to take full advantage of the knowledge of protection for both patients and employees. Hospital personnel are taught, as a matter of principle and good public health practice, to avoid all unnecessary exposure to ionizing radiation just as they avoid all unnecessary exposure to any of the communicable diseases. (See Chapter on Radiation Hazards.)

Ionizing radiations in excess of tolerable amount should be carefully guarded against. Methods for determining the required protective barriers and shielding are also given in Handbook 70, X-ray Protection, issued by the National Bureau of Standards.

The study of the publication prepared by the American College of Radiology, entitled: A Practical Manual on the Medical and Dental Use of X-rays with the Control of Radiation Hazards, should be a must for users of x-rays in hospitals.

To reduce the radiation exposure to patients, the following is a brief enumeration from the above Manual:

1. Provide sufficient filtration in the x-ray tube to absorb the soft useless rays.

2. Use an adequate diaphragm to confine the beam to the examined or treated area of the patient.

3. Use automatic exposure timing to minimize retakes.

4. Use restraining devices with children to minimize retakes.

5. Use faster films.

6. Use gonadal shields.

7. Be sure that there be no significant stray radiation or leakage.

8. Use only modern and well shielded equipment.

9. Use adequate darkroom facilities to prevent spoilage of film and consequent retakes.

10. Maintain good housekeeping to prevent dirt and static from spoiling films.

11. Use full dark-adaptation of the eyes to ensure maximum visibility of image, and hence shortest possible exposure period in fluoroscopy.

12. Use of optimum target-to-table distance of at least 18 inches in fluoroscopy.

13. Have periodic surveys made of all equipment by a qualified expert.

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Nursing Home Sanitation

Definitions

Exact meanings of legal and legislative terms are extremely important. The basic or enabling legislation should therefore define them clearly and accurately.

Nursing Home: One of the most difficult tasks in developing licensing legislation for nursing homes is formulating definitions that accurately and adequately define the types of facilities to be licensed. For licensure purposes a "nursing home" might be defined as:

An institution, building, residence, private home, or other place, part, or unit thereof, however named, whether for profit or not, including facilities operated by the State or a political subdivision thereof, which is advertised, offered, maintained, or operated by the ownership, or management, for a period of more than twenty-four (24) hours, whether for consideration or not, for the express or implied purpose of providing accommodations and care for two (2) or more individuals, not related to the owner or manager by blood or marriage within the third degree of consanguinity, and who are in need of nursing care and related medical services which are prescribed by or performed under the direction of persons licensed to provide such care or services in accordance with the laws of the State.

A shortened, less legally formulated definition of "Nursing Home" as used here means a facility or unit, however named, which is designated, staffed, and equipped for the accommodation of individuals not requiring hospital care but needing nursing care and related medical services prescribed by or performed under the direction of persons licensed to provide such care or services in accordance with the laws of the State in which the facility is located.

Home for the Aged: The following interpretation of the term is the one most commonly found in State licensing laws: A "home for the aged" means a facility, however named, which is designated, staffed, and equipped for the care of individuals who are not in need of hospital or nursing care but who are in need of assistance with the every day essential activities of living in a protected environment.

Residential Facility: A "residential facility," however named, means a hotel, motel, apartment house, boarding home, or other type of facility for the accommodation of individuals who do not need the kind of care given in a hospital, nursing home, or home for the aged.

Combination Facility: A "combination facility," however named, means a facility which has identifiable sections (in reasonable proximity and under the same overall management) in two or more of the following categories: Hospitals, Nursing Homes, Homes for the Aged, Residential Facilities.

Licensing of a "combination facility" poses certain difficulties. Each of its units is designated, staffed, and equipped to provide a particular complexity or level of care. Therefore, no one set of standards should be applied to the combination facility as a whole; instead, existing standards which apply to each constituent unit as such should be used. Moreover, it would be desirable for one inspector or one team of inspectors to inspect the entire facility and issue the necessary licenses for its operation.

Employee Physical Examinations

Each nursing home employee including the administrator should undergo a preemployment and an annual physical examination. These examinations should include laboratory tests, x-ray testing, and other tests for communicable diseases. The results of these examinations should be reported in writing and made a part of the employee's record.

No employee who is suffering from a serious physical or mental illness or has an active communicable disease should be employed in a nursing home. Nursing home employees who have missed 3 consecutive work days because of illness or accident should submit a doctor's statement concerning their fitness for work before they are allowed to return to employment. This statement should be made a part of the employee's record.

Physical Facilities

Site Selection: The site of a nursing home should be reasonably accessible to the center of community activities, physicians services and medical facilities, and located within the service area of a fire department. There should be good drainage, adequate sewerage, water, electrical, telephone, and other necessary facilities available on or near the site. Public transportation should be available within a reasonable distance. Adequate roads and walks and parking area should be provided within the lot lines. Sufficient space suitable for outdoor recreation also should be available. Compliance with all zoning codes and regulations must be required.

Noise: The requirements of older people for a quiet environment vary, and some patients prefer an area in which sounds of people and movements are present. However, proximity to sources of loud, continuous, or impact noise should be avoided. In general, the home should be remote from railroads, factories, airports, or similar noise sources. The outdoor noise level at a nursing home site should not exceed 50 decibels.

Air Pollution: Nursing homes should generally be located in areas reasonably free from noxious and hazardous smoke and fumes.

Insect and Rodent Harborage: The home site should be located so as to be remote from uncontrolled sources of insect and rodent breeding, such as open dumps, manufacturing plants where organic materials are processed, hog farms, barnyards, incinerators, and mosquito breeding areas such as swamps. Nursing home sites should be such that the ground slopes away from the buildings.

Submission of Plans: Nursing homes should submit carefully drawn plans of any proposed construction of new facilities or major alterations (in excess of a stipulated amount) to existing facilities to the licensure agency for approval. These plans should include complete details regarding the proposed construction, the exact location of all existing buildings, utilities, and any proposed future additions. Additions to substandard or marginal buildings should be discouraged.

Structure (General Building): Design Data - Nursing home buildings should be of sufficient strength to support all dead, live, and lateral loads without exceeding the working stresses permitted for the materials of their construction. Under applicable board codes, special provisions should be made for machine or apparatus loads which would cause a greater stress than that specified by the minimum live load. Nursing homes should be designed and constructed to withstand the weather conditions of the local area.

Foundations: Nursing home foundations should rest on natural solid ground, be carried to a depth of not less than 1 foot below the estimated frost line, or rest on leveled rock or load bearing piles when solid ground is not encountered. Proper weight-bearing values for the soil should be determined in accordance with recognized standards. Footings, piers, and foundation walls should be adequately protected against deterioration from the action of ground water.

Construction: One-story buildings should be of not less than 1-hour-fire-resistance construction, except that interior non-load bearing partitions, other than those enclosing corridors, stairways, and vertical shafts may be of non-combustible construction without a fire-resistance rating. Certain areas should have a higher fire-resistance rating than 1 hour. When this occurs the higher rating should be required as indicated in the Tables of Recommended Values for Various Physical Facilities in Nursing Homes in this chapter.

Structures built of other than noncombustible materials should adhere to the floor area restrictions set forth in any one of the national codes. For purposes of evacuation, the window sills of one-story buildings constructed of other than noncombustible material should not be more than 6 feet above the adjacent ground level and 36 inches above the floor level.

Buildings having more than one story should be constructed of noncombustible materials, using a structural framework of reinforced concrete or structural steel except that masonry walls and piers could be used for buildings up to three stories in height. The fire-resistance rating of the various building elements should follow the requirements of any one of the

recognized national codes, except as noted in the Table of Recommended Values. Building height limitations should be in accordance with the National Fire Association, Building Exits Code, Section 23.

General Requirements

Corridors: Nursing home corridors should have exits or open into corridors that have exits. All patient rooms should open directly into a corridor or to the exterior. Dead end corridors are undesirable and preferably should not be permitted. In no event should they exceed 30 feet.

Handrails should be required on both sides of corridors used by patients in nursing homes. They should be of an approved type and securely mounted to the wall in an approved manner. Signs, preferably of a lighted type, should be mounted in all corridors showing the way to the nearest exit.

Ramps: Ramps should be equipped with approved handrails or bannisters that are sturdily mounted. Ramp surfaces should be of nonslip material. Ramp slopes should be gradual so as to permit safe travel by wheelchair patients. Fire exit ramps should comply with the Building Exits Code. In many respects, ramps are similar to corridors in construction, therefore the same recommended values can be used for ramps and corridors.

Corridors and ramps which are not in areas used by patients should be constructed in a manner that is appropriate for the anticipated character of use. They should be at least 8 feet wide at elevators and wherever traffic would indicate a need for increase.

Stairways: Stairways should have evenly spaced risers and treads. Treads should be of a nonslip or safety tread type. If landings be used, they should at least be equal to the width of the stairway. "Winders" should not be permitted. All stairways and stairway landings should be equipped with handrails and/or bannisters on both sides. These handrails and/or bannisters should be of an approved height and type and should be firmly anchored to the floor or wall. Stairwells in nursing homes should be so designed or protected as to prevent an individual from falling or jumping from them.

Stairways should be enclosed with noncombustible materials and openings to stairways should be equipped with doors of the self-closing type. Each door should open in the direction of exit travel and be equipped with a vision window of wire glass. They should open on a landing and not directly on a step. Doorways or openings to stairways should comply with all standards relating to other doorways in nursing homes except that doors to stairways should be of 1-1/2 hours fire resistant rating. Doors should be incapable of being locked in the direction of exit travel. Doors opening directly to the outside should be equipped with approved panic release hardware.

Exits: At least two exits, remote from each other, should be provided for each floor or fire division of a building. One exit should be a stair or door leading to the exterior. The other exit may be a required stair, door to the exterior, or door to an adjacent area separated by a fire wall. Exits should be so placed that the entrance door of every patient's room and every point in dining room, and other rooms, be not more than 100 feet (along the line of travel) from the nearest exit.

All exits used by patients should be clearly marked with signs and a continuously illuminated light. The line of travel to such exits also should be clearly marked with arrows and signs. Where a corridor does not have an exit but terminates in one that does, an illuminated exit sign, including an arrow, should be located at the terminus.

Exit doors, in addition to meeting requirements of standard doors in the nursing home, should be of 1-1/2 hours fire resistant rating. Doors should be self-closing and incapable of being barred or locked in the direction of exit travel. Where it is desirable to keep such exits closed to access from the outside, panic hardware of an approved type should be used. All exits and halls must be kept free from obstruction. Exit stairways should have a minimum tread width and maximum riser height in accordance with Building Exits Code.

Doorways: All doorways through which patients pass should not be less than 3 feet 8 inches wide (3 feet 10 inches is preferable) except that doorways to individual toilets adjacent to patients' rooms may be 3 feet wide. Thresholds at doorways should be flush with the floor.

Interior doors, except for closets along corridors, should not swing into corridors, unless occupancy of a room be more than 25. They should be equipped with approved hardware that is easy to use. No doors to rooms used by patients, except for special requirements, should be equipped with locks or other devices designed to bolt or bar them.

Shafts and Chutes: All vertical shafts and chutes should be of 2-hour fire-resistant construction and vented directly to the outside at their tops. Each opening to these shafts or chutes should be equipped with a self-closing fire-resistant door or hatch of an approved type that has a positive latch.

Elevators and Dumbwaiters: Any new nursing home with patients on one or more floors above the main or ground level floor should have at least one electric motor driven elevator of sufficient size to carry a patient on a stretcher and an attendant. Nursing homes having a bed capacity of 60 to 200 beds above the main or ground floor should have not less than two elevators. In homes having above 200 beds, additional elevators should be required as needed. Elevators should not be counted as required exits.

Dumbwaiters when provided, should have cabs that are made of steel and should operate at a speed of 50 feet to 100 feet per minute when carrying a load of 100 lbs.

Shafts for both elevators and dumbwaiters should be of noncombustible construction of 2-hour fire-resistant construction. All openings should be equipped with fire-resistant doors having a self-closing device and a positive latch.

Utilities

Water Supply and System: The water supply available for the nursing home should be approved by and under the continuous surveillance of the State or local department of health. The water system should be free from cross-connections. Water supply requirements should include adequate provision for fire protection.

From the cold water service and hot water tanks, cold water and hot water mains and branches should be run to supply all plumbing fixtures and equipment. Toilets and urinals should be serviced with cold water only. Each main, branch main, riser, and branch of a group of fixtures of the water system should be valved. Pipes should be sized to supply water to all fixtures with a minimum pressure of 15 lbs. at the top floor fixtures during maximum demand periods. Every supply outlet or connection to fixture or appliance should be protected against back flow.

Hot water and circulating pipes should be insulated with covering equal to canvas jacketed 3 ply asbestos air cell. Cold water mains in occupied spaces, store rooms, and food preparation areas should be insulated with canvas jacketed felt covering to prevent condensation.

Plumbing fixtures should be of an approved nonabsorptive acid resisting type. Flush valves should be designed for quiet operation with back flow preventers and silencers. All fixtures should be installed in an approved manner that prevents cross-connection and back flow.

Each nursing home should have sufficient hot water heating equipment to supply at the point of use: 4-1/2 gallons of water at 125°F. per hour per bed for general fixtures, 4 gallons of water at 180°F. per hour per bed for kitchen use, and 4-1/2 gallons of water at 180°F. per hour per bed for laundry use.*

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*To qualify for Hill-Burton aid, 6 1/2 gallons of water at 125°F. per hour per bed is required for general hospital fixtures. For this purpose the F.H.A. requirement is the same.

The hot water storage tank or tanks should have a capacity equal to 80 percent of the heater capacity. Tanks and heaters should be of an approved type and be fitted with vacuum and relief valves, and where the water is heated by coal or gas, they should be equipped with thermostatic relief valves. All water heaters should be thermostatically controlled. Hot water tanks should be of corrosion resistant materials or otherwise properly protected against corrosion.

Electrical Installations: All electrical systems or alterations to existing systems in a nursing home should conform to the standards adopted by the National Fire Protection Association National Electrical Code. Electrical equipment should meet the standards of the Underwriters Laboratories Incorporated. Each area in the nursing home should be provided with sufficient electrical outlets to meet the use requirements of the area. Electrical systems and appliances must not be overloaded. Special attention should be given to laundry, food service, physical and occupational therapy, and other specialized areas.

The outlets for general illumination and nightlights in patients' rooms should be of an approved quiet operating type. General illumination and nightlight outlets in all other areas in the nursing home should be switched at the points of entry with approved switches.

Lighting: Adequate glare free lighting should be provided in all areas of the nursing home. In addition to general lighting, nursing homes should be equipped with nightlights in corridors, toilets, patient rooms, and similar areas to provide a lighting level of not less than 1 foot candle. The reading lights for each bed should have an illumination of at least 30 foot candles. There should be individual reading light facilities at each bed. Specific lighting values are found in the following Table of Recommended Values:

Area	Lighting Level in Foot Candles
Corridor and interior ramps	10
Stairways other than exits	20
Exit stairways and landings	5 - on floor.
Doorways	10
Administrative and lobby areas	30
Chapel and or quiet area	30
Physical therapy	20
Occupational therapy	30
Dining area	30
Recreation area	100
Patient care unit--General	10
Patient care unit--Reading	30
Nurses station	20
Utility rooms	20
Pharmacy area	30
Kitchen	30
Laundry rooms	30
Janitors' closets	15
Boiler rooms	20
Toilet and bathing facilities	20

The use of candles, kerosene oil lanterns, or other open flame methods of lighting should not be permitted in the nursing homes.

Nursing homes should have available, and in working order, an approved emergency electrical system. In homes of 10 beds or under, a system of automatic battery type lighting units as described in National Electrical Code, Section 700-22 should be permitted. These systems should provide for the lighting of corridors, stairwells, and exit ways, including exterior lighting at exits.

Heating and Ventilation: In all geographical areas requiring heated structures, a central heating system of sufficient capacity to raise temperatures in all parts of occupied rooms to a minimum of 75°F. during coldest periods should be provided. The heating system should be thermostatically controlled in one or more zones.

The necessary heating sources should be furnished in each room and occupied space to maintain a comfortable temperature. Heating fixtures should be properly shielded for the safety of the patient. Portable room heaters should be prohibited. Each heating source should be equipped with hand controls, except in those homes where individual room automatic control is provided.

Each nursing home should be well ventilated through the use of windows, forced air, or a combination of both. In bed rooms, the glass area for natural light should not be less than 10 percent of the floor area. The ventilating space for natural ventilation should not be less than 4 percent of the floor area. Each window which is used for ventilation should be screened with 16 mesh wire screening or equivalent at all times except that these screens could be replaced by storm windows during the cold season.

Rooms and areas which do not have outside windows and which are used by patients or nursing home personnel such as utility rooms, toilets, bed pan rooms, baths, sterilizer rooms, food storage rooms, etc., should be provided with forced or other suitable ventilation to change the air at least once every 6 minutes.

All stacks, exhaust systems, and other vents should open to the outside, preferably above the main roof. They should not be less than 10 feet from any window.

Sewage Disposal System: Every nursing home should be provided with an approved plumbing system which discharges to an approved public sewerage system wherever possible. Where an approved public sewerage system is not available, an individual sewage disposal system should be constructed. This system should be built in accordance with the requirements of the State or local authority having jurisdiction. In the absence of such requirements, Public Health Service Publication No. 526, Septic Tank Practice Manual, should be used as a guide.

Administrative Facilities

Administration: Each nursing home should have a separate room or rooms of ample space for the administrator and his administrative staff. It should be equipped with all the necessary office equipment, including provision for the safe storage of patients' valuables.

Lobby Area: Each nursing home should provide a lobby area. Public toilets for both sexes should be located convenient to this area. Public telephone service also should be available.

Ancillary Facilities

Chapel and/or Quiet Area: A chapel and/or quiet area should be provided in each nursing home.

Physical Therapy and/or Occupational Therapy Area: If a nursing home maintains a physical therapy room, and/or an occupational therapy room, these should be located where they are readily accessible to patients. They should be designed so as to permit privacy to patients receiving treatments. The equipment should be of a safe and approved type. Every effort should be made to insure the safety of patients and employees using the equipment.

If a nursing home does not maintain a physical therapy unit and/or an occupational therapy room, then it should provide a physical activity room. This room should contain sufficient space and equipment to permit simple exercises and training to be performed. Adequate space for the storage of equipment should be provided.

Dining and Recreation Areas: Each nursing home should have one or more dining areas for patients. Whenever possible this area should be located adjacent to the recreation area and separated from it by a folding door or partition.

The dining area should be adequately equipped with sturdy, easily cleaned furniture and equipment. Provision should be made, in planning and furnishing this area, for the accommodation of wheel chair patients.

If it be not feasible to provide a separate dining area, then the recreation area may be combined with the dining area. When this is done, there should be a sufficient number of portable and sturdy tables or individual free standing, solidly based trays of appropriate height available to accommodate 75 percent of the beds.

Each nursing home should provide one or more sitting and recreation areas which should be separate from the lobby and administrative area. It should contain sufficient furniture, lamps, and other materials to meet the recreational and social needs of the patients. This area should provide reasonable privacy for patients when talking with relatives, friends, case workers, and others.

Lawns, Gardens, Outdoor Recreation Areas: Whenever possible, nursing homes should provide outdoor garden and porch or lawn areas for their patients. These should contain safe, level pathways and an ample quantity of safe and sturdy outdoor furniture to meet the needs of the patients.

Pharmaceutical Services and Pharmacy Area

Storage, Packaging, and Labeling of Pharmaceuticals: Pharmaceuticals should be stored in locked cabinets. Only authorized persons should be in possession of keys to these cabinets.

Narcotics, barbiturates, and other habit forming medications should be stored in a locked and securely fastened box or drawer in the medicine cabinet or closet. Any withdrawals from this box or drawer should be noted in the narcotics register book. Poisons and medications marked for "external use only" should be kept separate from general medications and narcotics. This should be accomplished through the use of a separate storage cabinet for such articles or by partitioning the general medicine cabinet.

Biologicals and other medications requiring refrigeration should be kept in a refrigerator. If they be stored in refrigerators used for storing foods, the medications should be kept in a special locked tray or container which is clearly and legibly marked.

All medications should be kept in their original container unless transfer of the medication be done by or under the supervision of a pharmacist.

Each patient medication container should be clearly and adequately labeled in the pharmacy and should include such items as prescription number, name of drug, strength and quantity of drug, patient's name, physician's name, date of issue, and name of pharmacist or licensed pharmacy.

Any pharmaceutical containers having soiled or damaged labels should be returned to the issuing pharmacist or pharmacy for relabeling. The contents of any medication container having no label or an illegible one should be destroyed immediately. Only a pharmacist should label, relable, or alter labels on medication containers.

Disposition of Pharmaceuticals: Pharmaceuticals belonging to patients should be given to them when discharged or transferred if so authorized in writing by the attending physician. Unused quantities of prescription (legend) pharmaceuticals not given to a discharged patient under a physician's authorization should be destroyed or otherwise disposed of in accordance with applicable pharmaceutical laws and regulations.

Narcotics or barbiturates left by discharged patients should be disposed of in accordance with Federal and State laws and regulations. If the home maintains a bulk supply of pharmaceuticals which is under the supervision of a registered pharmacist, these narcotics should be returned to him for disposition.

Stock Supplies: Nursing homes which do not employ a registered pharmacist on a regular

basis to supervise their pharmaceutical service, should be permitted to stock, and have on hand, only those items that are regularly available without prescription at a commercial pharmacy. Nursing homes wishing to stock bulk prescription pharmaceuticals should employ a full or part-time pharmacist and should provide a special locked room for which only authorized persons should have keys.

Bulk narcotics should be kept in a safe in the drug room. This safe should be kept locked and only opened when the supervising pharmacist is present. The pharmacy area should be equipped with counter and shelf space for storage and handling pharmaceuticals. It should be equipped with a sink and running water.

All bulk medication containers should be clearly and accurately labeled. These labels should indicate such items as: The nonproprietary name and trade name (if any) of the pharmaceutical, its strength, the original amount contained in the bottle, the lot or batch control number, and the name of the manufacturer.

Nursing Facilities

Patient's Rooms: Nursing homes should contain no more than 4 beds per room. Means should be provided to give each bed privacy such as by use of flameproofed sliding curtains. Since the creation of a homelike atmosphere is one of the aims of the nursing home, one and two bed rooms are the most desirable.

Patients' rooms should be so located as to provide an outside exposure and should be located above ground level. They should be designed so as to provide adequate placement of furniture and facilities essential to patients' needs. Not less than 3-foot space should be provided between beds and between the sides of the beds and adjacent walls. No patient room should be more than three beds deep from the outside wall. Each room should be equipped with electrical outlets including at least one duplex outlet, located at each patient's bedside.

Each patient should have located at his bedside and available to him an intercom or other approved signaling device. This device should be of a type that registers at his bedside in the corridor directly outside of the room and at the nurses' station.

Each patient room should be equipped with a lavatory with both hot and cold running water except where adjoining bathroom facilities are provided. Single service towels should be available at each lavatory.

Each patient unit should be equipped with a hospital-type bed having swivel lock casters (beds adjustable for hospital and home bed heights are desirable) and mattress. The mattress should have at least four handles strong enough to permit carrying a person weighing 200 lbs. The unit should contain a bedside cabinet, an overbed table, a straight chair of a nonfolding type, a wardrobe, and an easy chair if at all possible. In addition, each patient unit should have available to it sufficient patient utensils and nursing equipment and supplies to meet the needs of each patient.

Nurses' Station: Each floor on which patients are cared for should have a nurses' station. Each nurses' station should service no more than 40 beds. It should be centrally located in relation to the beds served, and provide easy view of corridors outside all rooms.

The nurses' station should be adequate in size to accommodate such equipment as charting desk and chairs, chart rack, patients' signal system, telephone, and storage cabinet for supplies.

Each nurses' station should have a medicine room adjacent to it or a medicine preparation area containing well lighted locked medicine cabinets for the storage of patient medications. These cabinets should be equipped with special locked compartments or drawers for the storage of narcotics, barbiturates, paraldehydes, and similar drugs. The medicine room or the nurses' station should, if at all possible, have a small refrigerator for the pharmaceuticals requiring refrigeration.

A sink with hot and cold running water should be provided in the nurses' station or medicine

room. A work counter and cupboard should be adjacent to this sink.

Utility Room: Each floor and/or each nursing unit where patients are being cared for should have a utility room. The room should be designed and constructed to provide for the separation of clean and dirty work areas. Each utility room should be equipped with a suitable sink and other necessary facilities for cleaning, sterilizing, and storing appropriate equipment and utensils for patient care. These facilities should be of an approved type and of sufficient size and quantity to supply adequately the needs of the patients in the nursing unit it serves. Each utility room should be equipped for the proper cleaning and sanitizing of bedpans. Each utility room should be provided with a sanitary self-closing waste receptacle. Utility rooms should be well ventilated by forced air or other suitable ventilation. The type of ventilation used should be capable of providing a complete air change within the room every 6 minutes.

Storage Areas (Patient Care): Storage areas should be provided on each nursing unit adequate in size to accommodate large equipment such as wheelchairs, walkers, mechanical lifts, stretchers, and the like. Nothing that will impede traffic should be permitted in corridors, stairways, or exit ways. At no time should equipment be stored or left in corridors for extended periods.

Cylinders containing compressed gases and cans containing volatile liquids should be stored and used in accordance with the latest edition of the National Fire Protection Association Codes 56 and 565. The fire resistance of storage rooms for such cylinders should be at least 1 hour.

A cupboard or closet should be provided on each nursing unit for the storage of clean linen. The size of this cupboard should be adequate for the linen requirements of that unit.

Special Care Rooms: There should be an adequate number of well-ventilated rooms (no less than 1 for every 25 patients) maintained ready for immediate occupancy by patients suspected of or diagnosed as having a communicable or infectious disease, patients who develop acute illnesses while in the nursing home, and patients in terminal phase of illness. These rooms should be equiped with private toilet and lavatory facilities.

The lavatories in such rooms should be equipped with elbow, knee, or foot faucet control. These rooms should meet all applicable standards previously set forth for patient rooms.

Examining and/or Treatment Rooms: It is well to consider requiring a special room (or rooms) for use as an examining and/or treatment room. Such a room should comply with the Recommended Values for utility rooms and should be equipped at least with a small desk, metal storage cabinet, examining table, and high intensity examining light. Such a room should also have an appropriate sink with hot and cold running water and at least two duplex outlets.

Service Facilities

Kitchen: The kitchen should be located convenient to the dining areas. It also should be convenient to the service entrance for food deliveries and garbage and trash disposal. The kitchen should not serve as a passageway between work or patient areas and it should be used only for food preparation. Food service procedures should be in accordance with the U.S. P.H.S. Publication No. 934, Food Service Sanitation Manual (see Chapter on Food and Drug Control).

The kitchen should be ventilated with clean outdoor air and provided with exhaust systems which will discharge the air above the main roof, remote from any window, air conditioning, or venting system air intake. This exhaust equipment should change the kitchen air at least once every 2 to 3 minutes. The major portion of this air should be taken from cooking, dishwashing, and similar areas.

A well-planned kitchen layout and adequate food preparation equipment in good working condition are essential. The food service area should provide adequate space and facilities for receiving deliveries, storage, preparation, and serving of food, dishwashing, and refuse

disposal. This will differ with the number of meals served and many other factors. In larger nursing homes, it is desirable to have heavy duty type ranges, mixers, and refrigerators.

It is also desirable to have pots and pans, cooking equipment, trays and cutlery of heavy duty type standardized to size of ovens, refrigerators, and shelving for greatest use of space. Utensils or surfaces which come in contact with food should be free from cracks, crevices, and similar separations that could collect food and other matter.

Dishwashing area: Provision should be made for dishwashing facilities that are separate from food preparation and serving areas. This area should have approved equipment for washing and storing dishes, trays, and other utensils used in the serving and preparation of food. It is desirable to require the larger homes to install mechanical commercial dishwashers of an approved type. Dishwashing procedures should be in accordance with one of the methods described in the U.S.P.H.S. Food Service Sanitation Manual. Dishwashing areas should comply with the Recommended Values for the kitchen.

The dishwashing area should be ventilated by an exhaust system that discharges air above the main roof and remote from any windows. This system should exhaust the air from the dishwashing area at least once every 6 minutes, especially around the dishwashing equipment.

Refrigeration: Refrigerators of adequate capacity should be provided in all kitchens and other preparation centers where perishable foods may be stored. In the kitchen area, a minimum of 1.5 cubic feet of refrigerated storage space for perishable and frozen foods should be provided for each patient. Refrigeration should be supplied by mechanical means. Toxic or flammable refrigerants should not be used in buildings occupied by patients. The compressors and evaporators should be of sufficient capacity to maintain appropriate temperatures in refrigerators when they are being used under normal circumstances. Compressors should be of an automatic control type.

Nonperishable food storage: Should be commensurate with needs.

Floor Pantries: Consideration should be given to the need for floor pantries where the type of food service and/or construction requires such facilities. If needed, adequate space and equipment should be provided.

Laundry: Laundry facilities should be located in areas that are not used by patients and so placed as to prohibit their use as corridors or passageways. Separate areas should be provided for the storage of clean and soiled linen. Washers should be firmly anchored to the floor and placed so that their waste products empty into floor or other suitable drains. All washing equipment should be designed to have variable wash and rinse cycles. It is desirable that washers be of the commercial type.

Extractors, if used, should be firmly mounted to the floor and so located that their waste products empty into a floor drain. Extractors should be equipped with automatic safety stop brakes and shock absorbing equipment.

Laundries should be equipped with gas, electric, or other hot air drying equipment. Such equipment should be firmly anchored to the floor and vented directly to the outside. Dryer vents should be equipped with approved removable lint traps and capable of driving unducted air a distance of 50 feet from any opening into the building unless it be discharged above the main roof. All electrical laundry equipment should be suitably grounded in an approved fashion.

Janitor's Closets: One or more janitor's closets should be provided on each floor of the nursing home for the storage and maintenance of cleaning supplies and equipment. This closet should be equipped with hot and cold running water, a floor level sink, and shelves. The closet should be vented.

If there be more than one nursing unit on a floor in a nursing home, there should be a janitor's closet in each nursing unit as well as one in each major service department.

General Storage: Each nursing home should have storage space commensurate with its needs. This area should be waterproof, 1-hour minimum fire-resistant construction. Each storage area should be provided with sufficient sturdy, safe, shelving to meet its requirements.

Areas such as attics and spaces under stairways should not be utilized for storage. The storing of materials in these areas poses a potential fire hazard and an insect and rodent breeding area in nursing homes.

Record Storage: Sufficient record storage space should be provided to meet the needs of the home. Patient and other important records should be stored in fire-rated containers or in completely fire-resistant enclosures. Containers and enclosures should conform to the latest edition of minimum standards of the National Fire Protection Association.

Boiler Rooms and Steam Systems: All boiler rooms and mechanical equipment rooms should be well ventilated and should be of 2-hour fire-resistant construction. A positive source of combustion air should be assured. They should be located in areas that are not used for patient care. They should be designed and located so as to prohibit their use as corridors or passageways. Heating plant equipment must not be overloaded.

Boilers and hot water systems should have the necessary rating and capacity to supply the hot water and steam requirements of the nursing home. Boilers which supply high pressure steam for kitchens, laundries, sterilizers, etc., should meet the requirements of the applicable State and local codes for 125 pounds working pressure. Boiler feed pumps, return pumps, and circulating pumps should be furnished in duplicate, each of which has a capacity to carry the load. Blow off valves, relief valves, non-return valves, injectors, and fittings should meet State and local codes.

A system of steam and return mains and appurtenances should be provided to supply all equipment which requires steam. All steam mains, risers, and return mains should be valved separately. Each piece of equipment should likewise be valved on the supply and return ends.

All high pressure steam and return lines should be insulated with covering equivalent to not less than 1 inch four-ply covering. Heating mains in the boiler room, unheated spaces, unexcavated spaces, or where concealed, should be provided with covering equivalent to not less than 1 inch asbestos air cell.

Only authorized individuals should be permitted to enter boiler and mechanical equipment rooms. Signs should be posted at the entrance to such rooms, stating this fact and warning of the potential hazards present.

An area (a separate building is preferred) should be set aside in nursing homes for the maintenance and repair of equipment. This area should be of 2-hour fire-resistant construction and remote from areas commonly frequented by patients. Maintenance facilities should be so designed and so located as to prohibit their use as passageways or corridors. Maintenance facilities should have at least a workbench and closed storage for tools and other supplies. Approved closed metal cabinets should be provided for the storage of paints, solvents, oil, and other highly volatile and flammable substances. In smaller homes, maintenance areas can be located in boiler or mechanical equipment rooms. In larger homes, it is advisable to set aside a particular room or rooms for such use.

Drinking Water: Approved drinking fountains should be accessible and conveniently located for the use of patients. It is preferable that some of them be for the use of wheelchair patients.

Patient Bathing, Lavatory, and Toilet: Toilet and bath facilities should be provided in rooms separate for each sex on each floor occupied by residents. Water closets and lavatories should be provided in the ratio of 1 for each 8 beds and baths (or showers); as a minimum the ratio should be 1 for each 10 beds. If at all possible, toilet facilities should be provided in conjunction with each room or pair of rooms. Preferably, some of the toilet and bath facilities

should be equipped and designed for the use of wheelchair patients. Such additional facilities as are dictated by the design of the home and the needs of the patients to be cared for should be provided.

All toilets and bathrooms should be equipped with sturdily mounted handrails and/or grab bars located so as to provide ample assistance to the residents. Showers should be of the stall or other approved type without curbs. They should be equipped with grab bars, and have water controls of an approved type located in a convenient place for patient use. It is desirable to have a bench or other arrangement for patients who wish to sit while showering.

Bathtubs should be installed in a safe and approved manner and should be equipped with grab bars and approved water controls. Patient lavatories should be located at a height that allows wheelchairs to slide under them. Lavatories should have approved water controls firmly and safely anchored to the wall, and firmly mounted wall mirrors. Water closet stalls for patient use should have sturdily mounted approved handrails on both sides. Door hardware on water closet stalls should be of a type that operate from the inside and the outside. It is advisable to require that a connection with the nurses' call system be provided in all water closet stalls and toilet rooms.

Employee and Public Toilets: Separate lavatory and toilet facilities should be provided for the general public. These facilities should meet the same standards as patient areas except that grab rails and nurses' call system connections need not be provided. Locker room facilities including toilets and lavatories should be provided for employees. These facilities should be separate from those used by the public and by patients and should be commensurate with the needs of the home.

Plant Maintenance, Operation, and Particular Items of Housekeeping: The building should be maintained in a clean, safe, and orderly manner, and kept in good repair, using accepted practices and procedures. It should be kept free of hazards such as cracks, warped or loose boards, warped or loose tiles and loose or broken window panes. The health and safety of patients and personnel should not be endangered by a lack of proper building maintenance. The grounds should be kept in a sanitary, safe, and presentable condition. They should be free from refuse and litter. Areas around buildings, sidewalks, gardens, and patios should be kept clear of dense undergrowth.

Electrical, Mechanical, Water, Waste Disposal, Heating, and Fire Safety Systems: All electrical, mechanical, water supply and heating systems should be inspected regularly. Repairs should be made to maintain these systems in a safe and functioning condition. Electrical cords and appliances should be maintained in a safe condition. Frayed wires, cracked or damaged switches and plugs should be replaced. Excessive use of extension cords and exposed wiring should not be permitted. Sprinkler systems, fire warning systems, standpipes, fire extinguishers, private hydrants, panic hardware, escape routes, and fire escapes should be inspected regularly and any repairs necessary to insure their proper operation should be made immediately.

Staff: The housekeeping, laundry, food service, and maintenance staff should not give direct patient care except in accordance with nursing services policies and procedures.

Patient Rooms: Patient rooms should be cleaned, arranged in an orderly fashion, and well ventilated. If patients keep their own rooms clean, they should be supervised properly to insure the accomplishment of this function. After a patient has vacated a room, the room and all its contents should be thoroughly and completely cleaned, aired, and sterilized when necessary. Clean bed linen should be provided. All patient utensils should be washed and sanitized.

Floors: Polishes used on floors should be of a type which will provide a nonslip finish. Throw or scatter rugs should not be permitted. Floors should be maintained in a clean and safe condition.

Deodorizers: Odor control should be achieved by cleanliness and proper ventilation whenever possible. Deodorants should not be used to cover up odors caused by insanitary conditions or poor housekeeping practices.

Storage: Storage areas should be maintained in a safe and neat manner. Combustibles such as rags and cleaning compounds and fluids should be kept in closed metal containers. The lower edge of bottom shelf should be at least 6 inches above the floor and the space beneath open for cleaning. Attics, cellars, and similar areas should be kept clean of accumulation of refuse, discarded furniture, and old newspapers.

Laundry Handling: Laundry should be handled, stored, and processed so that spread of infection will be controlled and clean laundry provided. Soiled laundry should not be permitted to accumulate, and proper laundry formulas should be used.

Insect and Rodent Control: Nursing homes should be so constructed and maintained that the premises are free from insects and rodents. The premises should be kept clean and free from debris which provide harborage for insects and rodents.

Screening for Exterior Openings: Windows should be screened during the insect breeding season with 16 mesh or equivalent screening. Ventilation openings, such as ports for exhaust fans, should be equipped with covers that close automatically when the fan is not in operation. Doors and other openings should be equipped or designed to minimize the ingress of flies and other insects.

Insecticides: Insecticides and rodenticides may be highly toxic and flammable. They should be used and stored under carefully controlled conditions in nonpatient areas. They should not be stored in any food storage preparation or serving area. Care should be exercised to prevent accidental or intentional ingestion.

Refuse Disposal: If community collection services be not available, a well designed and operated system should be provided for prompt collection and disposal of all solid waste materials originating on the premises. Provision should be made to clean containers and to store garbage in areas which are separated from those for food handling, food preparation, and food storage areas. In hot climates, it is desirable to provide refrigerated storage for garbage. It is also desirable to recommend the use of water carried food disposal units, where such are permitted. The Recommended Values for kitchens should also be used for garbage rooms.

Prevention of Accidents

Causative factors leading to accidents are classified as "environmental" and "human". We will deal mostly here with the environmental factors.

Accidents rank second as a cause for incapacity in the nursing homes whereas accidents rank third in custodial facilities. The greatest majority of accidents involve falls. They result, in most cases, from falls due to slipping or tripping on the floor, sidewalk, furniture, stairs, bathtub, or falling from the bed, porch, window, commode, or chair. Of the injuries resulting from falls, more than half are hip injuries. By place of accident occurrence, the bedroom accounts for about two-thirds of accidents, while altogether, the bath, hall, yard, and dayroom account for a much smaller percent.

Although mentioned in various places of this chapter, the factors relating to prevention of accidents will be summarily repeated here. It is well to remember that safety requires constant vigilance on the part of the housekeeping staff, this includes proper instructions in accident prevention to ambulatory patients as well as hospital personnel.

Factors in a Hazard-Free Environment: 1. Handrails on both sides of halls or walkways and at steps, both inside and outside of home.

2. One-story structure with ramps should be encouraged. Where stairs are at present, they should be kept free and clean and should have easily accessible light switches at top and bottom.

3. Sufficient light on step to:

a. Eliminate glare and shadows.

b. Light both top and bottom steps.

4. Provide exterior ramps instead of steps when possible, and flush thresholds at doorways.

5. Prohibit use of scatter rugs.

6. Prohibit entrance of residents into kitchen and laundry.

7. In resident's room:

a. Rugs or carpets securely fastened.

b. No slippery wax or moisture on floors.

c. Beds of sitting height, that do not move easily (improper bed height can be a major factor in nursing home accidents).

d. Obstacles removed from the middle of the floor (footstools, cords, low furniture).

e. Well-balanced chairs in good repair and of proper height for individual patients.

f. Sufficient light for all quarters of the room and light fixtures properly grounded and the switch close to the bed.

g. No appliances with open flame or unguarded hot surfaces. Heating units should be properly vented.

h. All electrical equipment, Underwriters Laboratories approved, gas units approved by the American Gas Association and installed according to local codes.

i. Flammable liquids such as alcohol, pressurized sprays, and fuel oils removed.

j. Crutches of proper length with rubber tips for ambulatory patients needing such aid.

8. In resident's bathroom:

a. Nonskid surfaces - rubber suction mats or "safetygrip" strips provided for tubs and showers.

b. Dry floors - mop up all water or other spilled liquids from floors promptly.

c. Grab bars and handrails for commode, tub, shower, and walls, properly anchored.

d. Only properly grounded electrical equipment, away from tub and shower area.

e. Room heaters properly installed.

f. No temporary heaters.

g. Thermostatic control of hot water (125°F. maximum). Hot water faucets may be painted "red" for easy identification.

h. No medicine cabinet.

The Building: Modern buildings constructed for nursing homes must be fire resistant and must have most of the factors for fire safety built in. However, many nursing homes are

converted structures which do not have these characteristics and, therefore, certain minimum safety factors must be provided. Fire-resistant structural materials must be used to prevent collapse of the building and retard the spread of fire, particularly to escape or evacuation passages. Finishing materials, including paint and lumber, should be fire resistant.

Major considerations concerning exits and exit routes are: (1) Exits must be unlocked and open outwardly; (2) all floors above the first must have at least two exits per floor, reasonably remote from each other; (3) exits should be properly marked with lighted exit signs; (4) exits, doorways, stairways, corridors, and other passageways should be kept free from obstructions, and at no time should stairwells or corridors be used to store furniture or similar articles.

Connections with concealed spaces in walls or other areas of buildings must be blocked to prevent the spread of flames. Stairways used for emergency egress must be enclosed. Fire resistant doors must be provided at hallways, stairs, dumbwaiters, and laundry chutes.

Areas and activities which are inherently susceptible to fire should be segregated. Such activities or equipment as heating plants, storage and use of combustible materials, workshops and similar equipment and activities must be isolated within fire-resistant rooms.

Equipment such as heating plants, electrical systems, appliances and similar items must be properly installed, not overloaded, and used in a carefully prescribed manner.

Noncombustibles: The contents of a nursing home cannot be entirely noncombustible. However, readily combustible and highly flammable material must be kept to a minimum by prompt removal of rubbish and the use of noncombustible materials wherever practical. Noncombustible materials must be substituted for combustible materials wherever possible. This also applies to furnishings such as beds, chairs, bedside tables, and portable storage closets.

The Building Occupants: A trained staff member qualified to initiate emergency procedures must be on duty and awake at all times.

Careless smoking is responsible for about one out of four nursing home fires. Smoking in bed must not be permitted unless closely supervised. Smoking rules must be established and enforced for both staff and residents as a fire safety factor. Regulated or supervised smoking periods are recommended. The use of metal or glass ashtrays that do not afford a "lip" for placing burning cigarettes may provide some measure of safety.

Pets and Animals: Pets and animals should not be kept in nursing homes, unless specific arrangement for their care be made. At no time should pets be permitted to enter areas where food is being prepared, stored, or served, or where sterile techniques are observed.

Spitting: Expectorating in corridors or other public areas should not be permitted.

Disaster Plan: There should be available in each nursing home a written procedure to be followed in case of fire, explosion, or other emergency. Employees should be instructed in this procedure. This plan should include such items as: persons to notify, alarm signals, fire extinguisher locations, evacuation routes, procedures for evacuating helpless patients, and personnel assignments for specific duties and responsibilities.

The established evacuation plan must be tested and workable, and known to both staff and patients. The following are essential parts of such a plan:

1. Have an adequate and properly trained staff, with work schedules so arranged that sufficient help will be available within the building and on call, both day and night, to handle the evacuation of residents.

2. Have a clear understanding regarding available standby personnel and other assistance.

3. Formulate the evacuation plan in consultation with the municipal fire department so that all concerned will be able to function as a team and will be cognizant beforehand of any

special problems with which they may be confronted.

4. Be prepared to approach the task in a calm, businesslike manner, so as to suppress fear and panic among the residents.

5. Study the fire control features of the building and determine with the fire department whether initial action should be horizontal evacuation (movement on the same floor), vertical evacuation (movement to another floor), a combination of both, or immediate removal of all residents from the building.

6. Plan resident removal based on location and a predetermined system of priorities in accordance with physical condition.

7. See that all new employees are thoroughly trained in evacuation methods and procedures before allowing them to assume complete responsibility for the safety of residents.

Fire Extinguishers: Fire extinguishers should be located on each floor as well as in special hazard areas such as boiler rooms, kitchens and laundries.

These extinguishers should be of a type, capacity, and number to meet the needs of the home and comply with applicable State and local codes (see following table). Extinguishers should be listed by the Underwriters' Laboratories, Inc. or Factory Mutuals Laboratories, except that no extinguishers using toxic vaporizing liquids should be permitted. They should be located so that a person will not have to travel more than 100 feet from any point to reach the nearest extinguisher, and should be low enough for persons of short stature to reach comfortably. Extra extinguishers should be provided at each kitchen and at workshops or other hazard areas. They are a most valuable fire safety device, but only if the proper-type extinguisher be available to a person trained in its use and only if they be serviced after each use, or inspected at regular intervals. A false sense of safety may result when the staff members are not aware of the limitations of extinguishers.

Extinguishers should be inspected at least every year (oftener if so specified by the manufacturer) to see that they are in good working order. A tag or other device should be attached to each extinguisher or standpipe after such inspection to indicate that the inspection and servicing was done. Wnen at all possible, there should be a fire hydrant located within 300 feet of the nursing home.

Sprinkler Systems: Serious consideration should be given to the requirement that nursing homes be completely equipped with sprinkler-alarm systems. As a minimum, sprinklers should be required in those areas which are considered hazardous from a fire safety point of view. Such hazardous areas may include soiled linen rooms, basement corridors, paint shops, wood working shops, trash rooms, storage rooms, accessible attics, laundry and trash chutes, and entire nonfire resistant buildings.

Alarm Systems: Underwriters' Laboratories, Inc. or Factory Mutual Laboratories listed automatic fire alarm and detection systems providing complete coverage of the entire building should be installed in every nursing home. (It is preferred that the home be equipped with a sprinkler system which has an alarm device as an integral part of the system.) Every employee should be thoroughly familiar with the system and its use. The system should be inspected regularly and kept in good working order. The system should have a direct line connection with the local fire department whenever possible.

Fire Escapes: Outside fire escapes should be of an approved type. They should be kept clear of obstructions and in a safe usable condition. The fire escapes should have a minimum width of 42 inches and should be easy for patients to negotiate. Outside fire escapes should not be permitted in new homes.

Fire Extinguisher: Types and Characteristics

Type of extinguisher	For class of fire*	Agent and operating characteristics
Hand pump	A	Contains plain water; 2 1/2-gallon size lasts 50-55 seconds, discharges 30-40 feet; use on fires involving wood, paper, textiles, etc.; pump by hand.
Soda acid	A	Contains bicarbonate of soda solution; 2 1/2-gallon size lasts 50-55 seconds; use on wood, paper, textiles, etc.; discharges 30-40 feet; to operate, turn upside down.
Gas cartridge	A	Contains water and cartridge of carbon dioxide; 2 1/2-gallon size lasts 50-55 seconds; use on wood, paper, textiles, etc.; may also be used on small oil, grease, gasoline, or paint; discharges 30-40 feet; to operate, turn over and bump.
Foam	A and B	Contains solution of aluminum sulfate and bicarbonate of soda; 2 1/2-gallon size lasts 50-55 seconds; use on oil, gasoline, grease, and paint; discharges 30-40 feet; to operate, turn upside down.
Carbon dioxide	B	Contains liquid carbon dioxide under pressure; 15-pound size lasts about 42 seconds; use on oil, gasoline, grease, and paint; discharges 6-8 feet; to operate, pull pin and open valve.
Vaporizing liquid	C	Contains carbon tetrachloride and other chemicals; 1-quart size lasts 40-45 seconds; use on live electric equipment; discharges 20-30 feet; to operate, turn handle, then pump by hand (because of their extreme danger, carbon tetrachloride extinguishers should be discouraged).
Dry chemical	A, C	Contains bicarbonate of soda, dry chemicals, and cartridge of carbon dioxide gas; 30-pound size lasts about 22-25 seconds; use on live electric equipment; discharges about 14 feet; to operate, pull pin and open valve (or press lever), then squeeze nozzle valve. Also effective on Class A fires.

*Class A--wood, paper, excelsior, and other ordinary combustible materials.
Class B--flammable liquids, such as gasoline, kerosene, oil, and paint.
Class C--fire in electrical equipment, where the use of an extinguishing agent which does not conduct electricity is necessary.

References:

1. Nursing Home Standard Guide, U.S. Public Health Service Publication No. 827, 1961.
2. Nursing Homes: Environmental Health Factors: A Syllabus. U.S. Public Health Service Publication No. 1009, March 1963.

Recommended Values for Various Physical Facilities for Nursing Homes

	Corridors and Interior Ramps	Stairways (Other than Exits)	Exit Stairways and Landings	Administrative and Lobby Areas	Chapel and Quiet Area	Dining and Recreation Area	Pharmacy Area	Physical and Occupational Therapy and Physical Activity Area
Fire Resistance	1 hour	2 hours	2 hours	1 hour	1 hour	1 hour	2 hours	1 hour
Live Load Weight	1st Floor: 80 lbs./sq.ft. 2nd Floor: 60 lbs. sq.ft.	100 lbs./sq.ft.	100 lbs./sq.ft.	100 lbs./sq.ft.	100 lbs./sq.ft.	100 lbs./sq.ft.	60 lbs./sq.ft.	100 lbs./sq.ft.
Wall Finish	Smooth, painted, or similar surface	Smooth surface with painted or similar washable surface		Smooth, painted, or similar finish			Smooth, waterproof, painted, glazed, or similar finish	Smooth, painted or washable finish, waterproof at base
Flame Spread Rate Less Than	25	25	25	Lobby: 25 Adm. Area: 75	25	25	25	25
Floor Finish	Smooth, waterproof, non-slip, wear resistant	Tread and Landing: non-slip, and wear resistant	Non-slip, wear resistant	Smooth and wear resistant			Smooth, waterproof	Smooth, waterproof, wear resistant; Dry area - resilient, non-slip Wet area - hard tile non-slip
Ceiling Height and Finish	8' (7'6" with recessed lighting fixtures.) Acoustically treated	Equal to wall finish	Equal to wall finish	8' acoustically treated			8' painted, waterproof	8', smooth, painted, waterproof
Flame Spread Rate Less Than	25	25	25	Lobby: 25 Adm. Area: 75	25	25	25	25
Lighting Level	10 ft. candles	20 ft. candles	5 ft. candles on floor	30 ft. candles on floor		Dining area: 30 ft. candles Recreation area: 100 ft. candles	30 ft. candles Work table: 100 ft. candles Alcohol vault: 10 ft. candles	Physical Therapy - 20 ft. candles Occupational Therapy - 30 ft. candles
Other Features	Width of Corridors and ramps: 7 ft. (preferably 8 ft. for new construction)	3'8" width (between hand rails when they project more than 3½".	Door width of 3'8" minimum (larger size depending on population load)	Area is appropriate to size and need of the home		Area should be not less than 25 sq. ft. for 75% of total number of beds. Greater if needed.		Area size as needed

	Patient Care Unit	Nurses Station	Utility Rooms	Kitchen	Laundry Room	Janitor Closet	Toilet and Bathing Facilities	Boiler Rooms
Fire Resistance	1 hour	1 hour	1 hour	2 hours	2 hours	1 hour		2 hours
Live Load Weight	40 lbs./sq.ft.	40 lbs./sq.ft.	60 lbs./sq.ft.	80 lbs./sq.ft.	150 lbs./sq.ft.	60 lbs./sq.ft.	60 lbs./sq.ft.	150 lbs./sq.ft.
Wall Finish	Smooth, easily cleaned		Waterproof, painted or similar glazed finish: to a point above splash line	Base of wall waterproof and free of insect harborage	Smooth, waterproof, painted or similar surface	Base of wall free of insect and rodent harborage		Smooth, waterproof
Flame Spread Rate Less than	75(1) 25(2)	25	25	25	25	75	75	25
Floor Finish	Smooth, easily cleaned		Smooth, waterproof, wear resistance	Waterproof, grease proof, resistance to heavy wear		Smooth, waterproof wear resistant	Waterproof, wear resistant, nonslip	Smooth, waterproof, heavy wear resistant
Ceiling Height and Finish	8' Smooth easily cleaned		8', waterproof, acoustically treated	10', painted, waterproof, smooth, acoustically treated. May be lower with high capacity exhaust equipment.	Not less than 11", Except (3). Smooth, waterproof, painted surface.	8' minimum, waterproof, painted	8', 7'6" if lighting fixtures are completely recessed, and exhaust system is used for ventilation. Waterproof, painted.	12' minimum, except when domestic type heating units are installed.
Flame Spread Rate Less Than	Same as for wall	25	25	25	25	75	75	25
Lighting Level	General= 10 ft. candles Reading= 30ft. candles	20 foot candles		30 foot candles		15 ft. candles	20 ft. candles	20 ft. candles
Other Features	Single room area= 106 sq. ft., preferably 125 sq.ft. Multiple room area= 80 sq. ft. preferably 100 sq. ft.						Toilet area= 4'5" x 5' with at least one toilet 5'6" on each floor for training purposes. Shower Stall area = 4'x4'	

(1) Unit with not more than 4 patients.
(2) Unit with more than 4 patients.
(3) Where home style or small commercial-type laundry equipment is used and where adequate ventilation is provided.

Compiled from: Nursing Home Standards Guide Publication No. 827, U. S. Public Health Service, 1961.

Chapter XXXII

Control of Radiation Hazards

General

Although there has developed latterly an intensified interest in the public health aspects of radioactivity among public health workers, there has, nevertheless, been a slow persistent burgeoning of activity in this field during the years since the discovery of X-ray and radium. The intensive development of the use of X-ray and radium in medicine and industry and the growth of the use of radioactive luminous compounds have stimulated the creation of standards and formulation of rules and regulations for protection. Before this could have been effectively accomplished, enough scientific data had to have come into existence. In 1912, the International Radium Standards Commission began its work. In 1913 the National Bureau of Standards engaged in standardization activities and has been since that time a prime mover in this country in the development of protective measures. Its handbook H 23 entitled "Radium Protection" and handbook H 41 entitled "Medical X-ray Protection" are well known standard references. At present, in the widening field of nuclear fission and fusion[1], the U.S. Atomic Energy Commission has taken the limelight in fostering research for developing protective measures, and the National Committee on Radiation Protection has been engaged in formulating data into measures for safe handling. During all this time, public health agencies were steeped in the task of controlling communicable diseases and some of non-communicable etiology. Recent developments have forced the problem of radioactive hazards on the public health agenda.

The atomic energy industry, because of the hazards created by the nuclear fission operations, should be of interest to all levels of public health i.e., local, State and Federal, and, in some measure at least, to all classes of public health workers. Its importance to the national defense, to the economic future of our country and the rest of the world, to the public health, and to the public welfare has created a new era, and we should, therefore, be acquainted with the fundamentals of this new industry.

Ten years after the first U.S. nuclear power plant went into operation with a 90,000-kilowatt potential, the generation of nuclear electric power has increased more than 25 times. Fourteen plants, 1967, produced 2.3 million kilowatts, less than 1% of the nation's power. But by 1980, nuclear power is expected to account for more than 13% of the nation's anticipated 523 million-kilowatt capacity. By 1975, 80 nuclear plants are expected to be in operation in comparison to the 14 now in operation and 18 being built, with a capacity of 51.4 million-kilowatts, and by 1980 nuclear facilities are expected to have a generating capacity of 69.7 million kilowatts. This development plus the increasing use of radioactive materials in industry, medicine, and research means that the hazards from radiation continue to get greater so that they will become routine problems in the future for all trained personnel in environmental hygiene.

Although the industry is new and unique, the public health approach rests on established principles of sanitary engineering, industrial hygiene, and medical science. It is an industry where young men predominate, where new types of instruments are used, where highly refined and accurate techniques are necessary, where dealing with great speeds is essential and common, where operations require mammoth plants, where the epidemiologist deals with quantity and duration of radiations from materials rather than the type of virulence of infectious bacteria, and where a new type of public health worker has emerged to control hazards, namely, the health physicist.[2] The health physicist is a specialist whose position ranges between the sanitarian and the engineer. Some of his activity may appear to be that of the engineering fields, and some undoubtedly are identical to that of the sanitarian's functions. There is therefore much in the field of protection against radiation and the weapons of radioactive materials that falls to the responsibility of the sanitarian. The sanitarian will quickly recognize that many problems associated with the routine protection against radiation hazards, particularly in relation to radioactive contamination of water, waste, food, air and the like, are his responsibility, and that he must learn more about the nature of radiation in order to discharge these responsibilities with efficiency and finesse. The more dramatic functions of the sanitarian in this field are centered around the explosion of atomic weapons.

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1. Nuclear fission is the splitting of the nucleus of an atom into at least two other nuclei and the release of a relatively large amount of energy. Fusion is the combining of atomic nuclei to form heavier elements, releasing or absorbing relatively large amounts of energy.
2. A health physicist is in charge of carrying out the control measures against overexposure and proper disposal or radioactive materials at plants.

The Sanitarians Function During the Emergency of An Atomic Explosion

When a large amount of energy is released explosively, there is a considerable rise in temperature which results in the almost complete vaporization, or gasification of the products of explosion (or fission), and also of the container. The very hot gases so produced in a restricted space are at a very high pressure, and immediately following the explosion they start to move outward, that is, toward the external atmosphere where the pressure is lower. The great expansion which occurs then pushes away the surrounding air, water, or earth with considerable force, and thereby is initiated a complex series of effects which are responsible for the damage caused to structures and people. Whether the explosion occurs at a high or low altitude in the air, or at shallow or deep levels under water, or at various distances underground, the fundamental phenomena are the same, although differing somewhat in detail. The shock wave moves approximately with the velocity of sound. Since the temperature and pressure of the inner side of the wave is greater than that of the outer side, the inner side catches up with the outer and reinforces it. This produces the shock front of the wave which acts like a moving wall of highly compressed air or water. When this strikes a resistant surface, it produces the destructive blast effects or is reflected in another direction.

The pressure wave travels at such terrific speed that it leaves a temporary space of negative pressure in its wake almost equivalent to a vacuum. The vacuum space then becomes filled by a backwash of extremely hot air which fans the fires already started. Besides the blast effects, there are also two types of radiation which produce damages:

1) Thermal radiation from the ball of fire of the explosion has an extremely high temperature, ranging from over 1,000,000° C. to 300,000° C.), causing burns and conflagration.

2) Nuclear radiation causes physiological damage depending on the distance from the explosion. Large amounts cause death; small amounts may result in recovery after about 6 months. If the bomb bursts in the air, the residual radioactive fission products (emitting beta and gamma radiations) will become dispersed and dissipated and cause little or no deleterious effects. But if the explosion be underwater, the radioactive products will be concentrated in a limited area and become hazardous to life.

Of the small amount of radioactivity contaminating an area immediately after an atomic blast, 95% becomes dissipated after one hour, and 99.9% after the lapse of a day. It is the task of monitors to explore the affected area to make sure that circumstances have not allowed an undue concentration of radioactivity, and it is the task of the health physicist to treat such an area when found.

Let us see what the sanitarian can contribute to the alleviation of the people's lot who are caught in such a situation. The sanitarian's activities may be divided into three parts:

1) The anticipatory and planning phase.
2) The handling of emergency problems usual to disasters.
3) The handling of radiation hazards.

Anticipation and Planning

The alert sanitarian not only plans his routine work, but also tries to look ahead and to anticipate what he would and could do in case of an emergency. What is improbable today may be probable tomorrow. During unsettled world conditions, he hopes that man will be sane enough not to resort to the use of atomic weapons, but he prepared in case insanity prevails. The details of what he would do in an emergency cannot be foreseen, but he should be prepared with a general framework of a plan into which most details of activity would fit when the occasion arises.

a. He should be acquainted with all sources of potable water supply in the area of his jurisdiction and also those surrounding his area, and he should plan on how he would be able to utilize any of these water supplies, by cannibalization or otherwise, if any particular one became useless as the result of damage or contamination.

b. He should avail himself of enough understanding of the food supply problem so as to be able, quickly, to resort to a plan for obtaining food when local supplies have been destroyed or made useless by contamination.

c. There should be a general plan at hand for relocating people from affected areas, and for handling the housing, sewage disposal, water supply, insect and rodent problems in the relocation areas.

d. All planning should be done in cooperation with other agencies whose activities relate to this problem.

Usual Emergency Problems

The problems concerned with in this phase are those which would occur from fire, flood, tornado, earthquake or like disasters. The sanitarian's main role is protection of food and water and the application of his knowledge of basic sanitation under primitive conditions to excreta and waste disposal, temporary housing or camps, insect vector and rodent control, and similar matters. Knowledge of military field sanitation is an excellent aid to the sanitarian (see Chapter XXIX, Temporary Measures of Sanitary Control.)

Fires are important hazards resulting from atomic blasts. Knowledge of fire fighting and planning for such eventualities is essential. A sanitarian should know first-aid, but the medical phase is the province of the medical personnel. The latter should, nevertheless, be integrated with the sanitary planning.

Except for radiation hazards, the important sanitary dangers resulting from an atomic explosion are concussion and fire. Besides the injuries which these may produce on the body, the concussion may rupture both water and sewage pipes and destroy other sanitary facilities. Fires are destructive to shelter and food and may be responsible for destruction and damage of sanitary facilities.

The sanitarian must be continually cognizant of the fact that radioactivity cannot be destroyed by chemicals, boiling, sterilization, or any other technique used for ordinary decontamination. Knowledge of radiological monitoring is essential for effective control. Even though the sanitarian does not serve as a radiological monitor under ordinary conditions, he should understand the techniques used in monitoring and should know how to check food and water for contamination by radiation. Extreme emergency may force the sanitarian into monitoring activity. The more he knows about it the better he will be able to serve. One of the most important tasks of a monitor is to designate safe areas in a disaster zone which may be used for relocation centers and for areas from where rehabilitation and rescue personnel may operate.

Fission and fusion products remaining in the air or upon the ground as dust or mist render food and water useless if exposed thereto. If necessary, the sanitarian may have to decontaminate water supply by storage, chemical precipitation and filtration measures. Usually it may be assumed that foods packed in tin cans may not become contaminated by radioactive materials. Care must, however, be taken that contamination does not occur after the food has been emptied from the cans.

Nuclear Bomb Fallout:

The imminent war threats of today are megatons, fallout, and missiles. The magnitude of these threats to our existence is so horrendous that the only safeguard is peace. After the explosion, it is the fallout that matters. Fallout refers to the radioactive debris that falls to the earth's surface, resulting from an explosion of a nuclear weapon. There are 3 types of fallout:

1. The local fallout which is insignificant unless the fireball touches or comes too close to the ground. This is composed of larger particles and settles rather quickly.
2. The trophospheric fallout whose particles are fine and whose rate of fall due to gravity is nearly negligible. The material is carried in the atmosphere where rain and weather phenomena occur, i.e., in the trophosphere. This fallout occurs within two or three weeks or a month after the detonation, largely as a result of rain or snow. Usually, most of it falls in the latitude of the test site because of short residence time in the atmosphere.
3. The stratospheric fallout, composed also of fine particles negligibly effected by gravity, is caused by megaton (H-bomb) explosions. The stratosphere is above the trophosphere. It takes years (up to 10 years) for particles to settle out from this level. As these particles reach the trophosphere they settle out rapidly with rain and snow. Both trophospheric and stratospheric fallout becomes world-wide in distribution.

It is almost academic to discuss survival from blast in the immediate area of explosion. However, concerning exposure to fallout beyond this area, the National Committee on Radiation Protection and Measurements announced in a note of expectancy in January 1960 that the latest scientific research discloses that nearly anyone can receive up to 200 roentgens of radiation from a nuclear blast without suffering disabling illness.

The Committee declared that it is not realistic to follow the concepts of "maximum permissible exposures" appropriate to peace-time conditions in the event of nuclear attack. In war emergency, the exposure limits must be based on:

1. Protection from death due to acute radiation injury;
2. Protection from radiation injuries severe enough to require medical care;
3. Minimizing the long range effects of the radiation.

To allow for biological differences between exposures delivered during very short and very long periods of time, the concept of Effective Biological Dose (EBD) should be used which takes into consideration the recovery processes.

For any exposure above peace-time level, under emergency conditions, it must be expected that some degree of injury will occur. However, the human body has recovery processes which are capable of repairing a major portion of this injury except in cases where the dose is so great that death comes within a matter of days or weeks after the onset of exposure. Because of the existence of these recovery processes, individuals are able to survive exposures as high as 1,000 roentgens without becoming casualties if this dose were spread more or less evenly over a year.

The Committee recommended that an Effective Biological Dose of 200 roentgens be used as a reasonable guide in planning for survival under emergency conditions. In situations where exposure occurs over a few days or less, the actual accumulated dose and the EBD will be substantially the same. However, when exposure to radiation is spread over months or years, the actual accumulated dose may be as much as 5 times the EBD. Under either circumstance, the EBD is the controlling factor.

With very few exceptions, an EBD of less than 200 roentgens will not cause a disabling illness in people so exposed. The effects of exposure of less than 50 roentgens probably cannot be detected by any ordinary means. As the EBD exceeds 200 roentgens, the incidence of radiation sickness and the risk of death increases rapidly.

What all this means is that no person need become the victim of fallout if the advice about building shelters be heeded.

The Committee believes that even though few casualties would occur when the EBD is less than 200 roentgens, every effort should be made to limit exposure as much as possible below this level by providing adequate fallout shelter. The provision of adequate fallout shelter will probably become a family or group affair, since the building of community shelters does not appear to be in the offing at present, at least. "Home defense", therefore, takes on real meaning.

The problem of fallout and home defense was brilliantly discussed by Ralph E. Lapp in the May 1959 Bulletin of the Atomic Scientist. The following data on this subject is extracted therefrom: He stated that vast areas remote from the actual megaton* bomb bursts will be subjected to lethal radioactive fallout. The important fact about fallout is its persistence for weeks and months with high levels of gamma radiation. This external hazard is further complicated by the need for protecting the water and food (edible vegetation and animal life) against adulteration with beta-ray fission debris, and the intake of these into the body, thus creating an internal hazard. H-bomb detonation creates a high yield of long-lived beta-emitter fission products composed principally of strontium (Sr^{90}) with a half-life of 28 years, cesium (Cs^{137}) with a half-life of 26 years, ruthenium (Ru^{106}) with 1 year, promethium (Pm^{147}) with 2.6 years, and cerium (Ce^{144}) with 0.8 years. Of these, radiostrontium appears to be by far the greatest biological hazard due to its high yield, long half-life, wide diffusability, biological resemblance to calcium (therefore its tendency to replace calcium in biological processes).

In some cases where there are multiple bursts and strong winds, the lethal distance may extend to 500 miles from ground zero. Areas downwind of prime strategic targets will fall in this category. Primary lethality (lethality in the immediate area of blast) of megaton weapons centers upon a area 20 to 40 times smaller than that subject to lethal fallout.

Exposure hazard to fallout, based on 2 kilotons of fission debris per square mile, corresponds to a rate of 4,000 roentgens per hour, one hour after the bomb burst. The first

day radiation exposure depends very critically upon the time after detonation for the fallout to settle. It may require 1 hour for complete fallout close to the target, or as much as 18 hours further downwind. Reliable data on megaton-class fallout are fragmentary, but it appears that the major residual radiation threat does not occur within range of physical damage and that peak radioactivity never occurs at the crater but about 50 to 75 miles downwind.

The following table illustrates the roentgen dosage resulting from fallout for various time intervals after the explosion:

Roentgen Doses, In-The-Open, Resulting from Fallout of 2 Kilotons of Fission Products per Square Mile**

TIME INTERVAL	GAMMA DOSE	TIME INTERVAL	GAMMA DOSE
1 to 2 hours	2,500 r	2nd week	535 r
2 to 3 hours	1,250 r	3rd week	285 r
3 to 4 hours	800 r	4th week	140 r
4 to 5 hours	550 r		
5 to 10 hours	1,500 r	2nd month	220 r
10 to 24 hours	1,550 r	3rd month	100 r
		4th month	60 r
2nd day	950 r	5th month	40 r
3rd day	500 r	6th month	25 r
4th day	300 r		
5th day	225 r	6th to 12th month	60 r
6th day	175 r	2nd year	20 r
7th day	120 r	3rd year	6 r
		4th year	3 r

If we assume an effective time of fallout as 1 hour, the first day exposure to a person standing in the open would be about 8000 r, i.e., 2,500+1,250+800+500+1,500+1,550 (see table). Each hour that the fallout is delayed reduces the first day integrated dose by hundreds and thousands of roentgens, since the short-lived radioactive debris will have spent itself before settling. Thus, if we assume an effective time of fallout as 3 hours, the first day exposure will be only about 4,000 roentgens, i.e., one-half of what it was at 1 hour.

The fundamental rule for survival in time of fallout or suspected fallout is below-ground shelter. This evasion action must take priority over all other activities during the first few days following the outbreak of nuclear war.

The hours of grace before lethal fallout reaches the earth allow time for last-minute improvisation of radiation shelters. The ordinary basement provides a 10- to 20-fold reduction in radiation dose. Lying prone in one corner of basement gives further reduction. Still further reduction can be obtained by providing foxholes, or digging a tunnel in the basement wall, or by shielding with some dense material such as stacking up bags of coal, sand, or containers of water in a corner of the basement.

The holed-up survivors may emerge from cramped quarters after 2 or 3 days and enjoy more freedom of movement in the basement if the shelter protection had been great enough to prevent the exposure from surpassing 200 r for the first few days to a week. If that were so, limited excursions within the building would be possible for adults after the third or fourth day, since the external radiation would have dropped to 10 r per hour. (Calculation from above table: 24 hours divided into the average of 300 r and 225 r = about 10 r per hour). At the end of one week, the outdoor radiation level would drop to about 4 r per hour in open fields (it might build up to higher levels in built-up areas where the fallout debris naturally concentrates) and limited above-surface excursions could be made.

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*Megaton bomb refers to an energy equivalent of 1,000,000 tons of TNT, as distinguished from a kiloton bomb, referring to measurements in 1,000 tons of TNT energy equivalent.

**Assuming uniform spread of contamination, a bomb burst producing a fallout of 12 megatons of fission products distributed over 6000 sq. miles would produce an average of 2 kilotons of fission products per sq. mile.

After one week, a properly indoctrinated householder might attempt to reduce the contamination on the roof. It seems feasible that this may reduce the radiation by 10-fold for basement dwellers. The second week external dose of about 500 r should be guarded against so that exposure will be kept below 20 r and preferably below 10 r. The same rule applies for the 3rd and 4th weeks. Thus, the first month requires basement living unless decontamination had been effective.

During the second month, the outdoor levels of about 10 r per day are still too high for long-term above-ground movement. However, local decontamination and restricted movement plus indoor living as much as possible should keep the radiation dose below 10 r for this month. Thereafter the radiation exposures call for caution, but the problem is clearly no longer an acute one. At the end of one year, an untouched area should exhibit about 0.1 r per day, and the total dose in the second year would be about 20 r.

If the above schedule were kept for the first year after a blast, the accumulated radiation dose would amount to less than half of 1000 r, the limit beyond which radiation sickness and risk of death increases rapidly.

In order for the sanitarian to understand how and why radioactive materials may harm people, and the rationale of protective procedures, rules, and regulations against radiation hazards, it will be necessary to review some physical and chemical theory in relation to the structure of matter, particularly of the atom, just as an understanding of the public health aspects of communicable disease requires first an understanding of the nature of bacteria.

The Structure of Matter

An Element is a pure substance which cannot be broken down into simple substances by a chemical change. Example: Silver (Ag) cannot be separated into simpler substances by such change:

A Compound is a substance which can be broken down into simpler substances by a chemical change. Example: Silver Chloride (AgCl) can be broken down into pure elemental silver and into pure elemental chlorine. Silver nitrate (Ag NO_3) can be broken down into pure elemental silver, nitrogen, and oxygen. Ordinarily, however, silver nitrate will break down into silver and the compounded combination of nitrogen and oxygen (NO_3) which is called the nitrate radical[3] because the combination of one nitrogen atom and three oxygen atoms have the character of acting as a unit in many chemical reactions.

A Molecule is the smallest portion[4] of any substance (element or compound) which retains the same characteristics (the chemical identity) of that substance, i.e., if a piece of silver be separated into its smallest parts and each minute particle continues to retain the characteristics of silver, this element would then be separated into its molecules. In the same sense, if either silver chloride or silver nitrate be separated into its smallest parts and each minute particle continues to retain the characteristics of silver chloride or silver nitrate, then either compound would be separated into its molecules. Every molecule is composed of units called atoms, although in some instances, for example, silver, the molecule and the atom are identical.

An Atom is the simplest unit of an element which participates in a chemical reaction. Example: A molecule of silver chloride is a chemical combination of one atom of silver and one atom of chlorine resulting from a chemical reaction of these two elements; a molecule of silver nitrate is a chemical combination of one atom of silver, one atom of nitrogen, and three atoms of oxygen.

Rutherford's experiments (around 1912) indicated that the atom is composed of a very dense, small nucleus surrounded by a shell of much lighter particles (electrons) at relatively considerable distance from the nucleus, and that therefore much of the atom is empty space. Around the same time Niels Bohr presented his theory of atomic structure which is now generally the accepted theory, and which is used in the subsequent description of atomic structure.

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3. A radical is an atom or group of atoms which enters into and goes out of chemical combination without change, and which forms one of the fundamental constituents of a molecule.

4. The size of a molecule is about 10^{-8} cm. There are about 10^{23} molecules in the teaspoonful of water.

The Structure and Nature of the Atom.

Atoms do not decompose, nor are they synthesized by a chemical process. They are built up or broken down or transformed by a physical process called radioactivity. This process can be induced by the atoms being exposed to drastic bombardments with high-energy particles, or the process may be a spontaneous disintegration such as occurs in radium. The units of which the atom is composed are arranged like a minute planetary system. The center, or nucleus[5] of this system is composed of units, some of which have positive electrical charges (protons) and some of which have no electrical charges (neutrons.) Around this nucleus revolve negatively charged electric particles (electrons.) The number of electrons revolving around the nucleus depends on the number of positive electric charges in the nucleus. Thus, hydrogen, the lightest atom, has one positive charge in the nucleus and one revolving electron, while uranium,[6] the heaviest atom so far found in nature, has 92 positive charges in the nucleus surrounded by 92 revolving negative electric particles. Between these two extremes are all the various combinations of positive and negative charges which exist in nature and which constitute the different types of atoms of the various elements. Theoretically it is believed that these revolving electrons are orderly arranged in energy (or quantum) levels, or layers, or shells, and move in different planes. (Fig. 1). The first shell can have no more than 2 revolving electrons, the second shell no more than 8 revolving electrons, the third shell no more than 18, the fourth shell no more than 32, the fifth shell no more than 50, the sixth shell no more than 72, and the last or seventh shell no more than 98. According to this theory of shells, it is possible that there be 280 elements. But actually we know of only 103 (See Periodic Arrangement of Elements - Chart 1) elements at present and therefore there must be less than the maximum number of electrons in the various shells. No elements have been found in nature in which any of the last three shells for that particular atom contain their maximum number of electrons. There is also reason to believe that the outer shell, or the valency shell, of an atom never contains more than 8 electrons. From the actual knowledge which we have to date, the following practical general rules about electrons may be predicated despite of the above theory:

1) Electrons have a strong tendency to arrange themselves in complete shells which would give the atom stability.

2) The outermost shell of any atom except the first shell cannot contain more than 8 electrons, and the innermost shell cannot contain more than 2 electrons.

3) The highest number of electrons in any complete shell is 32.

4) The number of electrons in the outer shell (the orbital electrons) determines the valence of the atom.

The atom is the smallest unit of which a chemical element is built. All the atoms of an element are of a similar nature. Different elements have atoms of different natures. The number of protons in the atoms of elements determines their physical properties. The number of electrons in an atom governs the chemical properties of the atom. This is determined by the number of positive charges in the nucleus since, in the usually stabile conditions, the outer electrons can be no more than the number of positive charges (or protons) in the nucleus. The revolving electrons do not move around haphazardly but revolve in definite concentric orbits about the nucleus and, as stated, also in different planes.

The number of electrons in the outermost orbit of the atom determines the nature of the combining power (or valence[7] of the atom) with other atoms; for example, in the formation of water (H_2O), each hydrogen atom has only one orbit with one revolving electron which it loses in the process (giving each hydrogen atom a positive valence of 1), whereas the oxygen atom which has 6 revolving electrons in its outermost orbit must gain 2 electrons in the process (giving it a negative valence of 2). Thus two hydrogen atoms each with a positive valence of 1 unite with an oxygen atom having a negative valence of 2 to form H_2O.

On the other hand, radioactive transformation or disintegration depends not on the revolving electrons in the atom but on changes in the atomic nucleus[8]. Much concerning the atomic nucleus

5. The size of the nucleus is 10^{-4} that of the atom; the volume of the nucleus is that of a sphere with a diameter of about 10^{-12} cm. The nuclear density is tremendous, being 10^{14} times greater than water.

6. Heavier elements were discovered by laboratory methods recently, such as neptunium, plutonium, americium, curium, berkelium, californium, einsteinium, fermium, and mendelevium, but these have not, as yet, been found in nature. Their atomic numbers are respectively, 93, 94, 95, 96, 97, 98, 99, 100, and 101.

7. Valence means the quality which determines the number of atoms or radicals with which any single atom or radical will unite chemically or which it can replace (using the hydrogen atom, which has a combining power of 1, as the standard.)

8. Various types of radiation, however, may be caused by changes in the spatial position of electrons in their shells with respect to the nucleus.

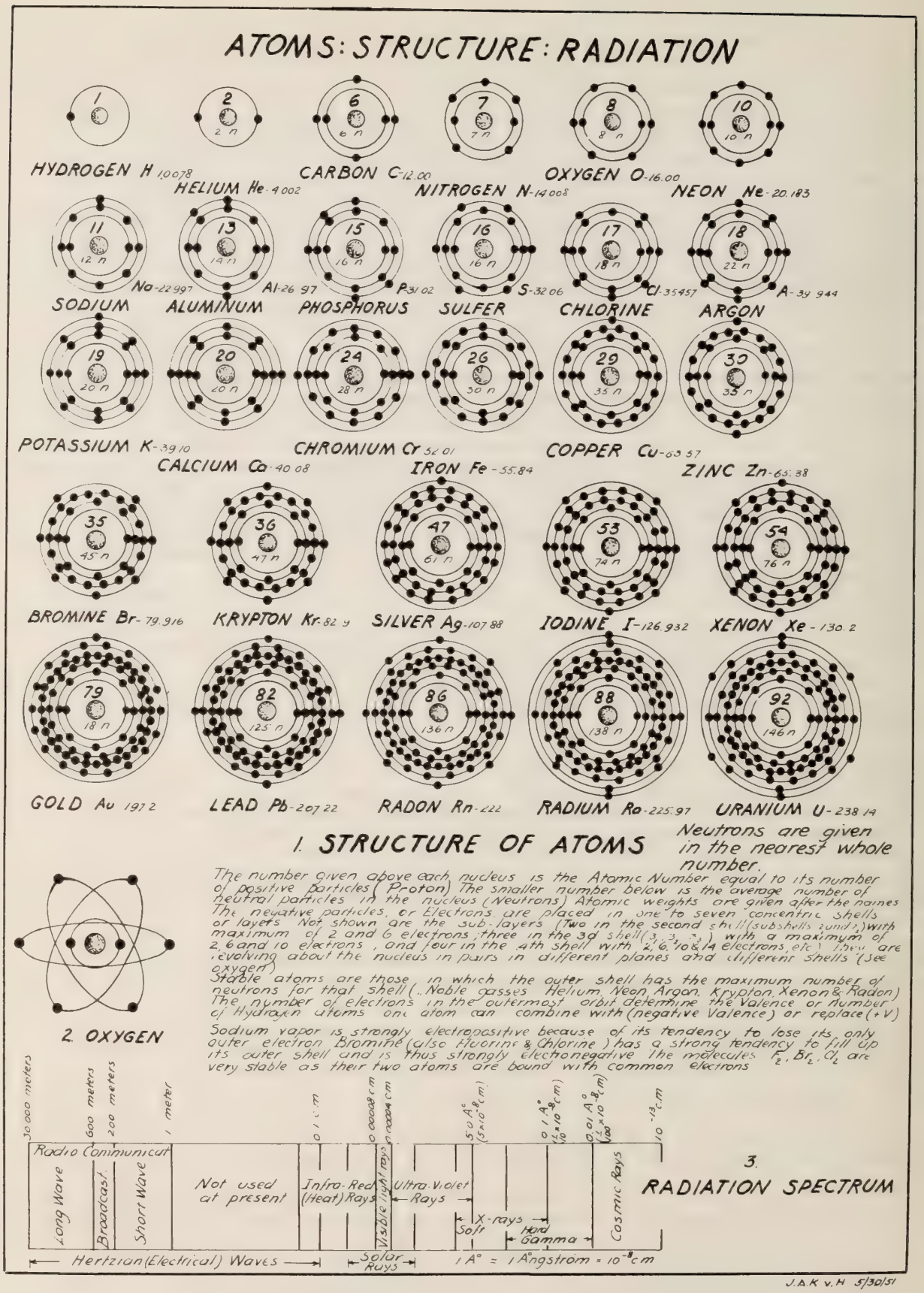
ATOMS: STRUCTURE: RADIATION
HYDROGEN H 1.0078
HELIUM He-4.002
CARBON C-12.00
NITROGEN N-14.008
OXYGEN O-16.00
NEON Ne-20.183
SODIUM Na-22.997
ALUMINUM Al-26.97
PHOSPHORUS P-31.02
SULFER S-32.06
CHLORINE Cl-35.457
ARGON A-39.944
POTASSIUM K-39.10
CALCIUM Ca-40.08
CHROMIUM Cr 52.01
IRON Fe-55.84
COPPER Cu-63.57
ZINC Zn-65.38
BROMINE Br-79.916
KRYPTON Kr-82.9
SILVER Ag-107.88
IODINE I-126.932
XENON Xe-130.2
GOLD Au 197.2
LEAD Pb-207.22
RADON Rn-222
RADIUM Ra-225.97
URANIUM U-238.14
1. STRUCTURE OF ATOMS
Neutrons are given in the nearest whole number.
The number given above each nucleus is the Atomic Number equal to its number of positive particles (Proton) The smaller number below is the average number of neutral particles in the nucleus (Neutrons) Atomic weights are given after the names The negative particles, or Electrons, are placed in one to seven concentric shells or layers Not shown are the sub-layers (Two in the second shell (subshells s and p) with maximum of 2 and 6 electrons; three in the 3d shell (3s, 3p, 3d) with a maximum of 2, 6 and 10 electrons, and four in the 4th shell with 2, 6, 10 & 14 electrons, etc.) These are revolving about the nucleus in pairs in different planes and different shells (See oxygen)
Stable atoms are those in which the outer shell has the maximum number of neutrons for that shell (Noble gasses Helium, Neon, Argon, Krypton, Xenon & Radon) The number of electrons in the outermost orbit determine the Valence or number of Hydrogen atoms one atom can combine with (negative Valence) or replace (+V)
2. OXYGEN
Sodium vapor is strongly electropositive because of its tendency to lose its only outer electron Bromine (also Fluorine & Chlorine) has a strong tendency to fill up its outer shell and is thus strongly electronegative The molecules F_2, Br_2, Cl_2 are very stable as their two atoms are bound with common electrons
30,000 meters
600 meters
200 meters
1 meter
Radio Communicut
Long Wave
Broadcast
Short Wave
Not used at present
Infra-Red (Heat) Rays
Visible Light rays
Ultra-Violet Rays
X-rays
Soft
Hard
Gamma
Cosmic Rays
3. RADIATION SPECTRUM
Hertzian (Electrical) Waves
Solar Rays
1 A° = 1 Angstrom = 10^{-8} cm
J.A.K v.H 5/30/51

Fig. 1 Atoms: Structure: Radiation

is still unknown. As previously stated, it is known that the nucleus is composed mainly of particles of positive electricity called protons, and neutral particles called neutrons. These types of particles are known as nucleons. Actually the neutron is a proton that is bound together with an electron (which has a negative charge) so that together the result is a neutral particle. The number of unbound protons (positive charges) in the nucleus is equal to the number of revolving electrons in the shells of the atom. Thus, since uranium has 92 revolving electrons, it also has 92

Chart 1 Periodic Arrangement of the Elements

No. of Orbits	GROUP I	GROUP II	GROUP III	GROUP IV	GROUP V	GROUP VI	GROUP VII	Group VIII and Stable Atoms
	The Atoms Grouped According to the Number of Outer (Valence) Electrons							
1	HYDROGEN H=1.0078 No. 1							HELIUM He.-4,002 No.2 — Atomic number - 2 End of the single orbit series
2	LITHIUM Li=6 940 No. 3	BERYLLIUM Be.=9.02 No. 4	BORON B=10.82 No. 5	CARBON C=12.00 No. 6	NITROGEN N=14.008 No. 7	OXYGEN O=16.000 No. 8	FLUORINE F=19.00 No. 9	NEON Ne.-20.183 No.10 — Atomic number - 10 (2,8) End of the double orbit series
3	SODIUM Na=22.997 No. 11	MAGNESIUM Mg.=24.32 No. 12	ALUMINUM Al=26.97 No. 13	SILICON Si=28.06 No. 14	PHOSPHORUS P=31.02 No. 15	SULFUR S=32.06 No. 16	CHLORINE Cl=35.457 No. 17	ARGON A.-39.944 No.18 — Atomic number - 18 (2,8,8) End of the triple orbit series
4	POTASSIUM K.=39.10 No. 19	CALCIUM Ca.=40.08 No. 20	SCANDIUM Sc.=45.10 No. 21	TITANIUM Ti=47.90 No. 22	VANADIUM V=50.95 No. 23	CHROMIUM Cr=52.01 No. 24	MANGANESE Mn=54.93 No. 25	IRON Fe=55.84 No. 26 — COBALT Co=58.94 No. 27 — NICKEL Ni=58.69 No. 28
	COPPER Cu.=63.57 No. 29	ZINC Zn.=65.38 No. 30	GALLIUM Ga=69.72 No. 31	GERMANIUM Ge.=72.60 No. 32	ARSENIC As=74.93 No. 33	SELENIUM Se=79.2 No. 34	BROMINE Br=79.916 No. 35	KRYPTON Kr.-82.9 No.36 — Atomic number - 36 (2,8,18,8) End of the four-orbit series
5	RUBIDIUM Rb.=85.44 No. 37	STRONTIUM Sr.=87.63 No. 38	YTTRIUM Y=88.92 No. 39	ZIRCONIUM Zr.=91.22 No. 40	COLUMBIUM Cb=93.3 No. 41	MOLYBDENUM Mo.=96.0 No. 42	TECHNETIUM Tc. - 99 No. 43	RUTHENIUM Ru=101.7 No. 44 — RHODIUM Rh=102.91 No. 45 — PALLADIUM Pd=106.7 No. 46
	SILVER Ag.=107.880 No. 47	CADMIUM Cd.=112.41 No. 48	INDIUM In=114.8 No. 49	TIN Sn.=118.70 No. 50	ANTIMONY Sb=121.76 No. 51	TELLURIUM Te=127.5 No. 52	IODINE I=126.932 No. 53	XENON Xe.-130.2 No.54 — Atomic number - 54 (2,8,18,18,8) End of the five-orbit series
6	CAESIUM Cs=132.81 No. 55	BARIUM Ba.=137.36 No. 56	LANTHANUM La=138.90 No. 57	CERIUM Ce.=140.13 No. 58				
				HAFNIUM Hf=178.6 No. 72	TANTALUM Ta.=181.4 No. 73	TUNGSTEN W=184.0 No. 74	RHENIUM Re.=186.31 No. 75	OSMIUM Os.=190.8 No. 76 — IRIDIUM Ir.=193.1 No. 77 — PLATINUM Pt.=195.23 No. 78
	GOLD Au=197.2 No. 79	MERCURY Hg=200.61 No. 80	THALLIUM Tl=204.39 No. 81	LEAD Pb=207.22 No. 82	BISMUTH Bi.=209.00 No. 83	POLONIUM Po.=209.99 No. 84	ASTATINE At. - 211 No. 85	RADON Rn.-222 No.86 — Atomic No.86 (2,8,18,32,18,8) End of the six-orbit series
7	FRANCIUM Fr. - 223 No. 87	RADIUM Ra=225.97 No. 88	ACTINIUM Ac=227.02 No. 89	THORIUM Th=232.12 No. 90	PROTOACTINIUM Pa.=231.03 No. 91	URANIUM U=238.14 No. 92	No. 93	Seven-orbit series is incomplete

ELEMENTS NOT CLASSIFIED IN THE TABLE

PRASEODYMIUM Pr.=140.92 No. 59 — NEODYMIUM Nd.=144.27 No. 60 — PROMETHIUM Pm.-147 No. 61 — SAMARIUM Sm.=150.43 No. 62 — EUROPIUM Eu.=152.0 No. 63 — GADOLINIUM Gd.=157.3 No. 64 — TERBIUM Tb.=159.2 No. 65

DYSPROSIUM Dy.=162.46 No. 66 — HOLMIUM Ho.=163.5 No. 67 — ERBIUM Er.=167.64 No. 68 — THULIUM Tm.=169.4 No. 69 — YTTERBIUM Yb.=173.5 No. 70 — LUTECIUM Lu.=175.0 No. 71

NEW ELEMENTS

NOTE: The following elements have been created in the laboratory in recent years, but have not been found in nature.

NEPTUNIUM, Np, At. No. 93, At. Wt. 239
PLUTONIUM, Pu, At. No. 94, At. Wt. 239
AMERICIUM, Am, At, No. 95
CURIUM, Cm, At. No. 96
BERKELIUM, Bk., At. No. 97
CALIFORNIUM, Cf. At. No. 98
EINSTEINIUM, At. No. 99
FERMIUM, At. No. 100
MENDELEVIUM, At. No. 101

unbound protons, and this "92" is known as the atomic number (also called the Z number). As has already been noted, the chemical properties which characterize an element are determined by the element's atomic number. **(Table 1)**

Table 1. Elements, Symbols, Atomic Number, and Mass Number

Element	Symbol	Atomic Number	Mass Number	Element	Symbol	Atomic Number	Mass Number
Actinium	Ac	89	227	Mercury	Hg	80	201
Aluminum	Al	13	27	Molybdenum	Mo	42	96
Americium	Am	95	241	Neodymium	Nd	60	144
Antimony	Sb	51	122	Neon	Ne	10	20
Argon	A	18	40	Neptunium	Np	93	237
Arsenic	As	33	75	Nickel	Ni	28	59
Astatine	At	85	211	Nitrogen	N	7	14
Barium	Ba	56	137	Osmium	Os	76	191
Berkelium	Bk	97	244	Oxygen	O	8	16
Beryllium	Be	4	9	Palladium	Pd	46	107
Bismuth	Bi	83	209	Phosphorus	P	15	31
Boron	B	5	11	Platinum	Pt	78	195
Bromine	Br	35	80	Plutonium	Pu	94	239
Cadmium	Cd	48	112	Polonium	Po	84	210
Calcium	Ca	20	40	Potassium	K	19	39
Californium	Cf	98	245	Praseodymium	Pr	59	141
Carbon	C	6	12	Promethium	Pm	61	147
Cerium	Ce	58	140	Protoactinium	Pa	91	231
Cesium	Cs	55	133	Radium	Ra	88	226
Chlorine	Cl	17	35	Radon	Rn	86	222
Chromium	Cr	24	52	Rhenium	Re	75	186
Cobalt	Co	27	59	Rhodium	Rh	45	103
Columbium	Cb	41	93	Rubidium	Rb	37	85
Copper	Cu	29	64	Ruthenium	Ru	44	102
Curium	Cm	96	242	Samarium	Sm	62	150
Dysprosium	Dy	66	162	Scandium	Sc	21	45
Erbium	Er	68	167	Selenium	Se	34	79
Europium	Eu	63	152	Silicon	Si	14	28
Fluorine	F	9	19	Silver	Ag	47	108
Francium	Fr	87	223	Sodium	Na	11	23
Gadolinium	Gd	64	157	Strontium	Sr	38	88
Gallium	Ga	31	70	Sulfur	S	16	32
Germanium	Ge	32	73	Tantalum	Ta	73	181
Gold	Au	79	197	Technetium	Tc	43	99
Hafnium	Hf	72	179	Tellurium	Te	52	128
Helium	He	2	4	Terbium	Tb	65	159
Holmium	Ho	67	164	Thallium	Tl	81	204
Hydrogen	H	1	1	Thorium	Th	90	232
Indium	In	49	115	Thulium	Tm	69	169
Iodine	I	53	127	Tin	Sn	50	119
Iridium	Ir	77	193	Titanium	Ti	22	48
Iron	Fe	26	56	Tungsten	W	74	184
Krypton	Kr	36	83	Uranium	U	92	238
Lanthanum	La	57	139	Vanadium	V	23	51
Lead	Pb	82	207	Xenon	Xe	54	130
Lithium	Li	3	7	Ytterbium	Yb	70	173
Lutecium	Lu	71	175	Yttrium	Y	39	89
Magnesium	Mg	12	24	Zinc	Zn	30	65
Manganese	Mn	25	55	Zirconium	Zr	40	91

The weight of an electron is negligible compared to the weight of a proton. Therefore the weight of the atom is composed almost completely of the weight[9] of its bound and unbound protons. Since uranium has 92 protons and 143 neutrons, and since the weight of a neutron is composed almost entirely of its bound proton, therefore the "atomic weight" (also called the mass number) of the uranium[10] atom is 92 + 143 or 235.

Each element can have only one atomic or "Z" number, but, however, each element may have more than one mass number or atomic weight. When an element exists in more than one form each of which differs from the other only in the mass number, as is the case for uranium, these forms of the element are spoken of an isotopic forms, or they are said to be isotopes of each other. Isotopes, therefore, differ only in the number of neutrons in the nucleus. Most elements in nature exist in two or more stable isotopic forms; a few are unstable. It is possible to produce unstable radioactive isotopes of all known elements. About 280 naturally found isotopes (mostly stable ones) and around 800 artifically produced radioisotopes (unstable) are known at present. Among the heaviest atomic species, there are those which have no stable forms.

If two distinctly different elements have the same mass number, they are isobares of each other. Isobares are therefore defined as elements with the same mass number but different atomic numbers. For example, plutonium has a mass number of 239 and so does uranium -239 have the same mass number, but whereas the former has an atomic number of 94, the latter has an atomic number of 92.

The neutrons and protons within the atomic nucleus are held together by the most powerful forces known. The latter forces are more than a million times stronger than the chemical forces which, for example, hold oxygen and hydrogen together in the water molecule, while the chemical forces are, in turn, many times stronger than the elastic forces which hold the molecules, for example, of a lump of steel together. The strength of the nuclear forces can be measured by the Einstein formula[11], $E = MC^2$ which describes the interrelation of Mass and Energy of the Law of Conservation of Mass-Energy.

Thus, the interaction of the elements of two substances without change in the elements themselves is known as chemical reaction, and the energy released is chemical energy; for example, in the combustion of carbon, it unites with oxygen to form carbon dioxide releasing at the same time chemical energy, a good deal of which is heat: $C + O_2 \rightarrow CO_2 +$ heat. Atomic energy, on the other hand, is that associated with the forces that hold the components of the atom together which determine the basic physical nature of atoms. In a chemical reaction, therefore, atoms of the same kind are present before and after the reaction. But is it possible for a reaction to take

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9. The proton mass is about 1840 times as great as the electron mass.

10. There are 4 known isotopes of uranium having atomic weights of 234, 235, 238, and 239, each having respectively 142, 143, 146, and 147 neutrons and 92 protons.

11. Because the binding forces between the neutrons and protons in a nucleus are very much greater than those between the atoms in a molecule, the amount of energy released in a nuclear reaction, particularly in fission, is considerably greater than that liberated in a chemical process. The calculation of energy-mass change is made by the Einstein formulation, $E = MC^2$, in which E equals the energy (in ergs) released, M equals the decrease in mass (in grams), and C equals the velocity of light (in centimeters per second) or 3×10^{10}. C^2 therefore is equal to 9×10^{20}.

When 1000 grams of uranium-235 undergo fission, the decrease in mass is just about 1 gram, i.e., 1 gram is transformed into energy. Therefore

$$E = 1 \times 9 \times 10^{20}$$
$$E = 9 \times 10^{20} \text{ ergs or } 2.1 \times 10^{13} \text{ calories}$$

The Hiroshima or Nagasaki atomic bomb released about 2×10^{13} calories which is equivalent to 20 tons of TNT. Therefore the release of energy of uranium-235 is equivalent to 19,000,000 times as much energy as released by the same weight of TNT.

place within the atom whereby the relationship of its components change, thus changing the physical nature of the atom while at the same time releasing the tremendous atomic energy stored therein?

Nuclear Transformation

Becquerel's findings that a photographic plate, protected against strong light, was affected if placed in the proximity of uranium ores was followed by the Curie discovery of radium in natural uranium ores. It is now known that radium is a decomposition product of uranium, and in turn is changed into the stable gas, radon, or into francium, polonium, bismuth and finally into stable lead; this is called chain decay. There are three such radioactive series or families, deriving from uranium, thorium and actinium, each forming its own "isotope" of lead. Natural lead, therefore, is a mixture of these three isotopes. We shall see also that Uranium-235 can be split into other elements outside the radioactive family, like Barium-137 and Krypton-83 (See Fig. 6 - 13); or by chain decay, after being split into two different mass fission chains, into Molybdenium-103 and Tin-131, to end respectively in Rhodium and Iodine-Xenon (See Fig. 5 - 6). This radioactive disintegration consists of emanations of three different types: alpha rays, beta rays, and gamma rays.

In 1919, Rutherford found that when alpha particles bombarded[12] nitrogen, then a heavy isotope of oxygen and hydrogen was formed, (See Fig. 222-6):

$$_7N^{14} + {}_2He^4 \longrightarrow {}_8O^{17} + {}_1H^1$$

Rutherford therefore showed that the physical nature of the atom could be transmuted, and opened up the field for a new horizon in physical science. Later is was shown that an atom of hydrogen with an atomic weight of 1 can be made to react with an atom of lithium with an atomic weight of 7, by means of fission or splitting action on the latter atom, to form 2 helium atoms, each with an atomic weight of 4: ${}_1H^1 + {}_3Li^7 \rightarrow {}_2He^4 +$ energy.[13] In this instance both the hydrogen and lithium atoms lose their identity and together form 2 helium atoms, at the same time releasing a great quantity of atomic energy. In the chemical reaction producing a molecule of CO_2, the amount of energy released is 4.1 electron-volts; in the nuclear reaction above, forming two atoms of helium, the amount of atomic energy released is 17,000,000 electron-volts per atom of lithium consumed. The atomic energy released, therefore, is millions of times greater, weight for weight, than the chemical energy released.

A chemical reaction depends upon the movements of the outer electrons of the atom, and the rearrangement of the atoms themselves, while radioactive transformation depends on the movement or redistribution of the nuclear particles of the atom. It can be seen then that if the nucleus of the atom could be split into neutrons and protons, fantastic quantities of atomic energy would be released, i.e., the energy which binds the neutrons and protons would be set free.

Why is not atomic energy obtainable practicably[14] by "nuclear burning" of hydrogen and lithium to form helium, and why is it practicable to burn coal for producing chemical energy? The answer is that once coal (or any other chemical fuel) is ignited, it has the ability to continue a self-maintained fire, i.e., it will continue to burn because the amount of energy (heat) released (energy liberation) by the initial reaction between the carbon atoms and oxygen atoms is greater

12. Due to the smallness of the nucleus target area, the repulsion of the positively charged particles by the positively charged nucleus, and the so-called "barrier energy" necessary to disturb the nuclear stability, the chances that the alpha particle, shot into the nitrogen, will strike the nitrogen nucleus are about one in 100,000. It has been estimated that at least 10^8 particles are needed to cause the disintegration of one nucleus.

13. In symbolizing expressions or formulae relating to atomic structure the following representations are used: ${}_ZX^A$ or X^A_Z where X stands for the symbol of the element, Z for the atomic number of the element, and A for the mass number of the element.

14. A new discovery has been made to directly harness the energy (beta particles) of atomic radiation. It is a battery-like arrangement which turns the radiations coming from the radioactive material into electric current. Radioactive strontium-90 is a waste product formed in atomic reactors when uranium-235 atoms split. The electrons from the strontium-90 pass thru a wafer of silicon, and in doing so, each such high speed electron breaks loose many electrons from the silicon atoms which in turn flow out as current. Such a "battery" begins to operate when the strontium-90 is brought to within a critical distance of the silicon. Thus the current can be controlled by controlling this "critical" distance. Strontium-90 has a half-life of 25 years. This gives an idea of the effective life of such "battery." The mechanism is still in its embryonic stage of development, but the principle involved is basic and the possibilities are fantastic.

than that amount of energy needed to initiate more carbon and oxygen atoms to react. The energy required to initiate such a reaction is called "activation energy". Thus, with each reaction between a carbon and an oxygen atom enough energy is produced to activate another reaction and the excess energy is given off as heat. This makes for a chain reaction. Such a continuous process does not occur when a hydrogen atom and a lithium atom are stimulated to react. Therefore it would take a great deal more energy to make such hydrogen and lithium atoms to react than the resulting energy from the reaction, i.e., the energy put into causing the reaction would be greater than the energy resulting from the reaction. Such a process is uneconomical and impractical. The latter picture, however, began changing in the middle 30's.

Nuclear Fission

It was found in 1936 by Hahn and Strassman that if a neutron could be released from an atom and allowed to bombard the nucleus of uranium, the nucleus would split into barium, krypton and several other elements in the middle of the periodic table, and release a great amount of energy (200 Mev per reacting nucleus). This is known as nuclear fission. The important question here is: Is the activation energy required for releasing a neutron to strike an uranium atomic nucleus as great or greater than the amount of energy released as the result of the fission produced?

The amount of "activation energy" required for the reaction of different substances varies. The easiest nucleus to attack is the one which requires the least activation energy, such as carbon, lithium, boron, etc. It has been found that uranium has a very low activation energy with a very high energy liberation, and therefore, should be a good source for obtaining tremendous sources of energy. On the other hand, tin (Sn) needs the large activation energy of 50 Mev which is much higher than that of any neutrons. Terbium (Tb) needs 20 Mev but the neutrons produced have only energies between 1 and 2 Mevs.

Neutrons need not possess energies as high as the activational energy in order to penetrate the potential energy barrier of the nucleus. According to the quantum theory there are leakages of less energetic neutrons through the barrier. The percentage is very small for low energy neutrons, but grows with the energy, and is 100% for those having energies as high as the fission activational energy. So-called resonant particles can leak through the energy barrier. Thus thorium, with an activation energy of about 9 Mev, will undergo fission by neutrons of only 1 Mev energy. Out of every 25 neutrons which get into the nucleus of thorium, (which has 90 protons and 142 neutrons), only about one will cause fission and the other 24 are ejected from the nucleus again at a lower energy than that with which they entered, due to energy loss as gamma rays.

As a general rule, it can be assumed that it requires more activation energy to cause nuclear fission in stable elements than in unstable elements because the nuclear forces within the atoms of stable elements, where the ratio of protons to neutrons is 1:1, are well balanced, as compared with unstable elements where the ratio of protons to neutrons approaches 1:1. 6, and the relations of nuclear forces are imbalanced.

With U-238, out of every 5 neutrons getting into the nucleus, one is able to produce fission, and although we get neutrons as a fission product, we spend more neutrons than we get back. It is only for U-235, the rarer isotope of uranium, that the fission activational energy is less than 5 Mev and also less than the re-emission activational energy, so that fission is more probable than re-emission of the neutron. More than one out of every two neutrons used will produce fissure, and since each nucleus produces two neutrons on fission, we get more than we put in. A self-sustaining reaction is therefore possible. This is like-wise the case with Neptunium and Plutonium, of which only the latter can be used on account of the short half-life of Neptunium.

Therefore, U-235 supports a continuing process whereby practically every neutron which is emitted by a piece of U-235 under certain conditions can cause the fission of an atomic nucleus with the emission of two more neutrons. Each of the latter two neutrons may then split an atom so that together they would liberate four neutrons. Then if each of these four were further to split another atom, all four would liberate 8 neutrons (Fig. 3). This chain reaction is what happens in the explosion of an atomic bomb. Thus, a self-perpetuating process of fission and release of atomic energy had been discovered.

When atoms of U-235 break apart into 2 middle size atoms (barium and krypton) as the result

$$_7N^{14} + _2H^4 \longrightarrow {}_8O^{17} + {}_1H^1$$

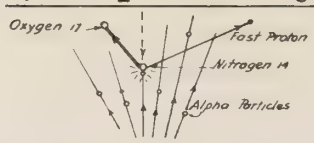

Fig. 2 First Nuclear Reaction in Laboratory --Rutherford's Experiment (See Fig. 6 - 6)

Fig. 3 Chain Reaction

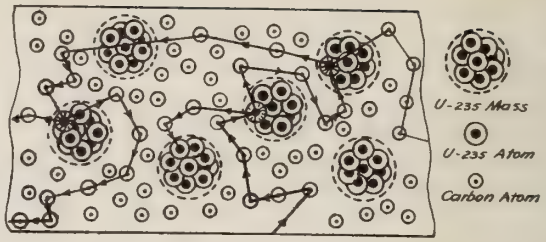

Fig. 4 Slow Neutrons in Uranium Pile

of fission and at the same time liberate several more free neutrons, the total mass of the two resulting middle-size atoms is slightly less than the mass of the uranium atom. The difference appears as an enormous amount of energy according to the Einstein law of mass-energy equivalent, i.e., the small amount of mass is transformed into an enormous amount of energy (about 200, 000, 000 electron-volts per atom split.) This self-perpetuating or chain reaction continues until all the uranium-235 has disintegrated.

It is necessary to understand some of the conditions under which fission may take place to grasp the idea of chain reaction. A chain reaction can be set up by the use of pure fissionable material such as uranium-235, or plutonium, or by the use of ordinary uranium which contains small amounts of uranium-235. Fission of ordinary uranium is, however, mainly the fission of its U-235 content since U-238 requires too many neutrons for the reaction to be self-sustaining.

Fissionable material, as has already been explained, is in a continuous process of disintegration and thereby is constantly giving off fast moving neutrons. These neutrons move so fast and so freely through atoms that they may pass through the atoms without splitting them, or may pass out from the surface of the piece of fissionable material without affecting its atoms. If the piece of fissionable material be large enough so as to reduce the surface-to-volume ratio, and therefore reduce the probability of a fast moving neutron escaping from the surface of the lump of material, then the probability of a fast moving neutron being "captured" by an atomic nucleus and splitting the latter becomes greater. The size of the lump of fissionable material that will sustain a continuous process of splitting nuclei and thus produce a chain reaction is called the "critical size." Fast moving neutrons can therefore produce a chain reaction in a lump of pure fissionable material of the critical size or larger. The critical size for a lump of non-pure fissionable material, such as a mixture of U-235 and U-238, can be decreased by higher U-235 content and molding its shape closer to a spherical form. At the correct critical size, the chain reaction is so fast and the release of energy so great that the result is a gigantic explosion. This is another basic principle of the atomic bomb.

A slow, controlled chain reaction may, however, also be set up by the use of ordinary or natural[15] uranium and slow moving neutrons. It was found that slow moving neutrons with energies of only 1/40 ev and velocities of $\frac{1}{200,000}$ that of light could leak through the potential energy barrier, penetrate a nucleus, and cause fission. Since the only motion and energy that such neutrons possess are thermal, they are often called "slow or thermal" neutrons. Such neutrons are produced by causing fast moving neutrons to slow down by collision with atoms of other substances (known as "moderators"), and then allowing them to return to the uranium mass with reduced speed.

Uranium pile (See Fig. 4). The practical application of the above mechanism is effected in the "uranium pile," consisting of small chunks of uranium compound placed as a lattice between masses of carbon which act as a "moderator" by retarding the speed of neutrons and then reflecting them back to the uranium where they can act. A small quantity of radium and beryllium

15. Natural uranium is a mixture of various uranium isotopes, most of which is the non-fissionable (i.e., does not disintegrate spontaneously) uranium-238 and 1 of which is fissionable uranium-235.

is also placed in the pile to act as a source of neutrons. The fission of each atom of U-235 will produce two neutrons and 200 Mev of energy. This energy will be the kinetic energy (after deduction of gamma rays) of the fission products such as krypton and barium (See Fig. 6 - 13), which will continue moving and colliding until all this energy is dissipated as heat. As the result of fission, two neutrons will be ejected. If the moderator material be much greater than the uranium compound, they will be slowed down and be absorbed by the uranium, etc. The neutrons, even when not causing fission, are not lost unless being captured by U-238, or escaping through the surface. Only one effective neutron produced per fission will make the pile self-sustaining. Increasing the size of the pile will minimize the surface neutron loss. Purity of materials, etc., can be regulated so that for each two neutrons produced by a fissioning atom, one will maintain the chain reaction, and the other will be absorbed by U-238.

Control of the pile is extremely necessary to prevent an explosion. Suppose each neutron produced gives in time 1.05 neutrons effective in producing further fission. After 100 steps the available neutrons would be $(1.05)^{100} = 100$, after 200 steps, 10,000, after 300 steps, 1,000,000, etc. for each original neutron sent into the pile. As the time for each reaction is 10^{-6} second, an explosion would take place before any control steps could be taken. It will thus be necessary to absorb a number of neutrons. This is done by inserting into the pile rods of cadmium or boron steel which have a high affinity for slow neutrons. The deeper these rods are inserted into the pile, the slower the reaction becomes, and entirely embedding the rods may bring the reaction to a standstill.

Moderators. A material which can cause the slowing down of the movement of neutrons without absorbing them is called a moderator. Among the best and most economical of moderators is pure carbon. Heavy-water[16] is a good moderator also, but not as economically available. The moderator atoms slow down neutrons by acting as a buffer or shock absorber against their impact.

Plutonium. The neutrons in a uranium pile, besides producing fission of U-235, may also be absorbed by the nuclei of U-238. When such a nucleus captures a neutron, the atom changes from $_{92}U^{238}$ to $_{92}U^{239}$. In 20 minutes the latter atom emits a high speed electron (a beta particle) spontaneously from the nucleus and changes into a new element, neptunium ($_{93}Np^{239}$), with an atomic weight of 239 but with one greater positive charge (i.e., 93) on the nucleus than uranium-239. In 2 days the neptunium atom emits a high speed electron from its nucleus and is transformed into plutonium ($_{94}Pu^{239}$) with an atomic weight of 239 and a positive nuclear charge of 94. The latter is highly unstable and therefore radioactive. Since this is a different element from uranium, it can be easily separated from the uranium by chemical means.

Radiation (See Fig. 1-3, 5, and 6)

When an atom gives off a particle or a ray from its structural make up, the process is known as radiation. These particles travel at very high speeds, some of them approaching the speed of light (186,000 miles per second). When a filament in a tube is subjected to a very high voltage, atomic radiations are given off from the filament which can penetrate materials and effect a photographic plate. These radiations are known as X-rays. As has already been mentioned, there are certain elements which naturally give off atomic radiations at all times and in doing so gradually change their natures and become transformed into other types of elements. These elements, such as radium, thorium, uranium, and plutonium, are therefore called radioactive. During this process of transformation, which is actually a process of decay and growth of radioactive materials, any atom of a radioactive element may disintegrate at any instant regardless of its age or of ordinary chemical or physical influences. Radioactive decay can occur in 5 ways (4 of which may give rise to a nucleus which differs chemically from the parent or original.) These are alpha particle emission, beta or negatron decay, positron decay, orbital electron capture, and gamma-ray emission. Radioactive decay occurs as the result of atomic instability and the tendency toward seeking stability.

Basic Factors in Atomic Stability and Instability (Chart 2)

1) Within the nucleus, very strong forces of attraction exist between neutrons and protons, and also between neutrons themselves.

2) Protons, being positively charged, repel one another with a force approximately

16. Heavy water is water in which nearly all the hydrogen is the heavy isotope called deuterium. Deuterium is hydrogen which, besides a proton, also contains 1 extra neutron in the nucleus.

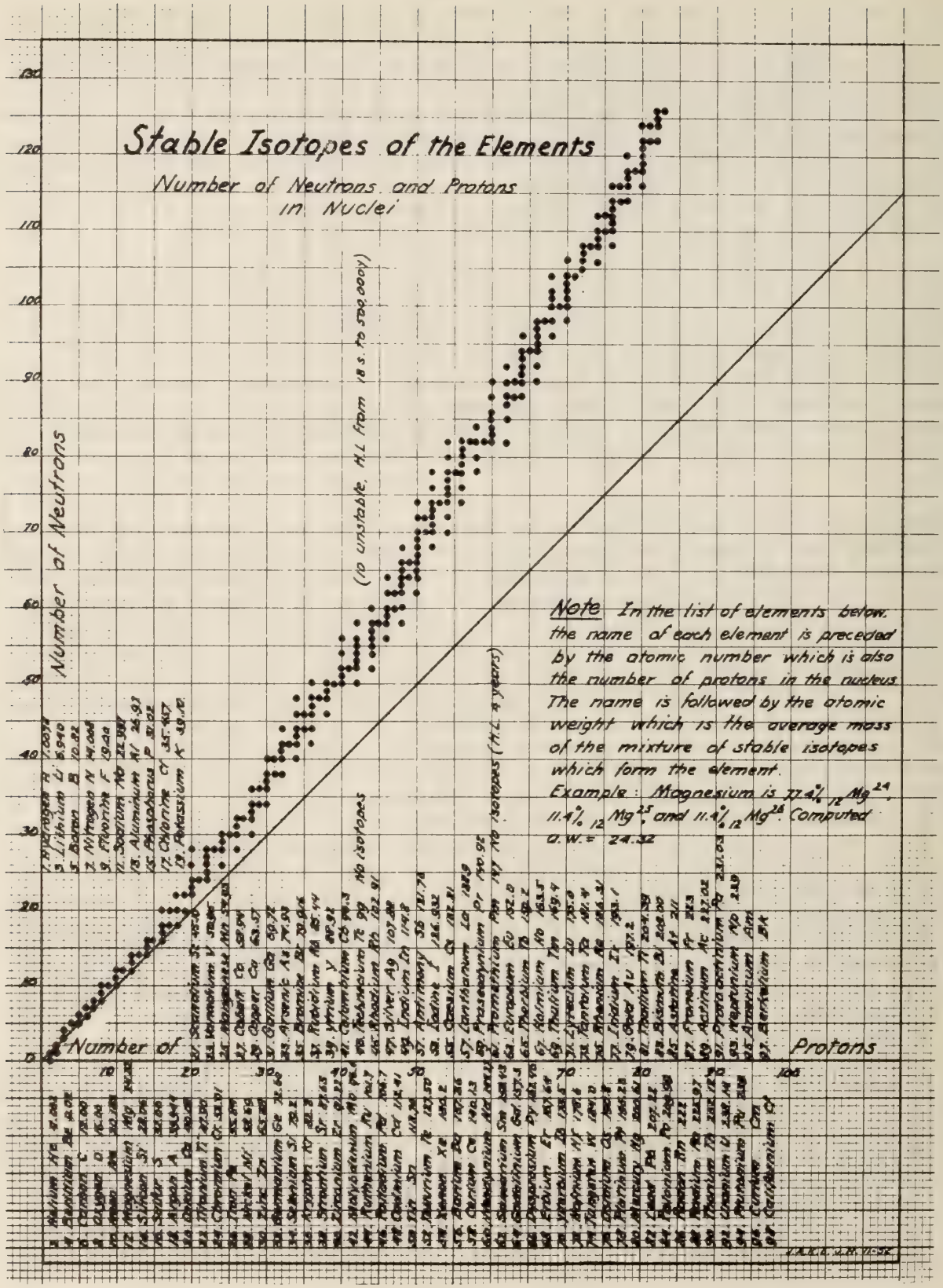
Stable Isotopes of the Elements
Number of Neutrons and Protons in Nuclei
Number of Neutrons
Number of Protons
(no unstable, H.L. from 18 s. to 3×10^9 y.)
(H.L. 4 years)
Note In the list of elements below, the name of each element is preceded by the atomic number which is also the number of protons in the nucleus. The name is followed by the atomic weight which is the average mass of the mixture of stable isotopes which form the element.
Example: Magnesium is 77.4% $_{12}Mg^{24}$, 11.4% $_{12}Mg^{25}$ and 11.4% $_{12}Mg^{26}$. Computed a.w. = 24.32

Chart 2 Stable Isotopes of the Elements

proportional to the square of the number of protons present.

3) The stability of a given nucleus is determined by the balance between these forces of attraction and repulsion.

4) As the atomic number increases, the number of protons in the nucleus and hence the magnitude of the force of repulsion increases rapidly and the relative stability can be attained only as a result of increasing the number of neutrons. The increased attractive force then counteracts, to some extent, the force of repulsion.

5) In spite of the increased number of neutrons which serves to provide some degree of stability in the nuclei of atoms of high mass number, the resultant binding force between the nucleons is smaller than it is in nuclei of lower mass number. Therefore the relative stability decreases as the mass of the nucleus increases.

A particular atomic species or isotope is stable when the "proton-to-neutron" proportion in the nucleus lies close to a 1:1 ratio. The various types of atoms between the 1:1 and 1:1.6 proton-to-neutron ratios each has its own stability ratio depending upon whether it is a light, medium or heavy atom. The ratio of stability increases from 1:1 toward 1:1.6 as the atomic mass becomes heavier. But around the 1:1.6 ratio, most of the atoms tend to become unstable. Thus a helium atom has 2 protons and 2 neutrons and therefore has a proton-to-neutron ratio of 1:1. The helium atom is very stable. A radium atom has 88 protons and 138 neutrons and therefore has a proton-to-neutron ratio of about 1:1.6. This element is unstable and is in a continual process of disintegration. The nuclei with proton-to-neutron ratios ranging around 1:1, are those of atoms in the lower range of atomic weights, while the nuclei with ratios approaching 1:1.6 are those of atoms in the higher range of atomic weights. Therefore, in the natural form, the atoms with lower atomic weights are the most stable, while those with the highest atomic weights are the most unstable. Instability may be induced in atoms with the lower atomic weights. Unstable atomic nuclei tend toward becoming stable in various ways such as follows:

Beta Radiation: Beta rays emitted by radioactive substances are highenergy negative electrons. The energy with which the beta particle is emitted depends upon the radioactive atom. With the exception of a few high energy beta rays of about 10 Mev, most beta rays range from very low energy up to 3 Mev. The ionizing power of beta rays, because of the small mass, is much smaller than that of alpha rays. Whereas a 3 Mev alpha particle produces about 4000 ion pairs per mm. travel in air, a 3 Mev beta particle produces only 4. But the alpha particle would have a range of 1.7 cm. against 1,300 cm. for the beta particle because the latter loses so little energy on ionization. The velocity of beta rays of 3 Mev and over approaches that of light. Since the mass is $\frac{1}{7,000}$ that of an alpha particle, the electron is easily knocked out of the way and its path is highly erratic as compared to that of an alpha particle.

Production beta rays can result directly from:

Elastic collision: A gamma proton with the speed of light collides with an electron, such as one of the 2 helium electrons, thus obtaining part of the photon energy and forming a beta ray. The atom has now a positive charge and is therefore ionized. (Fig. 5 - 1) Photoelectric effect: A low energy gamma ray photon comes close to an orbital electron. All photon energy is absorbed by the electron which is thereby expelled, forming a beta ray with ionization of the atom. (Fig. 5 - 2) Pair Production: Passing close to the nucleus of an atom, all photon energy of the gamma ray is transformed into a pair of electrons, one with positive (positron) and one with negative charge, each of which moves in its individual path. (Fig. 5-3)

Negative beta activity. If the nuclei of an isotope contain more neutrons or less protons than is required for stability, a neutron, by expelling a negative electron (called a negatron or negative beta particle) will change into a proton and thereby transform the atom into that of another element. If this does not bring stability, the process is repeated until stability is attained. Example: ${}_8O^{16}$ (oxygen) is built up to ${}_8O^{19}$ by neutron absorption, and finally is changed into ${}_9F^{19}$ (fluorine) by beta ray emission (Fig. 5-5). Fig. 5-6 shows how beta rays are emitted as the result of uranium fission by negative beta chain decay, reducing the number of neutrons in the fission products.

Positive beta activity. Similarly as above, when the number of neutrons in the nucleus is too small or protons too great for the proton-to-neutron ratio to be within the stability range, the proton will tend to change into a neutron by ejecting a positive electron or positron. This process goes on until stability is reached. A positron is the same size and mass of a negatron. It is emitted only by the lighter isotopes with induced radioactivity. Among the heaviest elements, no positive beta activity has been observed. A positron may unite with an electron, and both may change their material form and become electromagnetic energy of the gamma ray type. Example: Carbon-11 (having 6 protons) emits a positron and changes into boron-11 (having 5 protons.) This type of radioactivity is called "positive beta activity". In Fig. 5-4, $_{30}Zn^{64}$ becomes $_{30}Zn^{65}$ by neutron absorption and is reduced to $_{29}Cu^{65}$ by positive beta radiation.

The effect of beta ray activity can be excitation, ionization, or X-ray emission. Excitation of the atom occurs when, by collision with a beta particle, an orbital electron is knocked out of place and into a wider orbit. A certain amount of energy is imparted to the atom which is gradually lost in the form of heat (Fig. 5-7). Ionization occurs when a beta ray has sufficient energy to knock an electron out of its orbit and away from the atom (compare Fig. 5-8 to Fig. 5-1). X-rays have their origin in the electron shells or levels surrounding the atomic nucleus of atoms with high atomic number. For X-rays to be emitted, there must be a vacant place among the electrons of the atomic layers around the nucleus. Such vacant places are produced by the ionization of an atom when other atoms or molecules collide with sufficient intensity with it or when a high speed electron collides with it causing the removal of an electron from the shell, or when an atom absorbs a primary radiation which is capable of causing such a removal. It requires the absorption of a certain quantum[17] of energy to cause an electron to be displaced or to jump from an inner to an outer orbit around a nucleus. The further removed from the nucleus the orbit is to which the electron jumps the greater the amount of energy in the quantum (therefore the greater its frequency and the shorter its wave length.) Then when the electron returns or jumps back to its inner orbital position, it emits the previously absorbed energy, and the amount of energy in the emitted radiation of X-ray will depend on how far back its jump will be. (See Fig. 5-8 and 9)

K (orbital) electron capture. (Fig. 5-10) In an unstable atom with too low neutron to proton ratio, an electron from the nearest orbit (K orbit) is sometimes captured under favorable conditions to reduce the number of protons. A free electron is then attracted into the orbit to complete the atom structure. Of course, the element is changed into another one: $_{26}Fe^{55} \longrightarrow {}_{25}Mn^{55}$; $_{31}Ga^{67} \longrightarrow {}_{30}Zn^{67}$ We have seen that this also can be achieved by ejection of a positron from a proton. (Fig. 5-4)

Gamma-ray Emission. Radioactive changes are frequently accompanied by the emission of penetrating radiations called gamma rays. These are electromagnetic radiations, related to light rays and X-rays, but of shorter wave length (i.e., higher energy.) Shorter and longer gamma rays are identical so that the radiations are indistinguishable. The term gamma is, however, used to describe the radiations of short wave lengths which have their origin in atomic nuclei. The emission of gamma rays represents an important way in which a nucleus, in a state of high (internal) energy (i.e., excited nuclear state) can rid itself of the excess energy. (See Fig. 5-6 and 9 and Fig. 6-11 and 13).

17. A quantum is a discrete quantity of energy (in the form of electromagnetic waves) which is symbolized as q, equal to the product of the wave frequency (or the number of vibrations per second) which is symbolized as n, and a constant factor called Planck's Constant, which is symbolized as k. Therefore the formula for the amount of energy in a quantum is $q = n\,k$.

Note: A "meson" is the energy particle, or the "cement" that binds together the protons and neutrons that form the atomic nucleus. It is short-lived and carries a positive or negative charge, or no charge at all, and seems to exist as two types, the heavier type with a mass of about 320 times that of an electron, and the lighter type with a mass of about 200 times that of an electron.

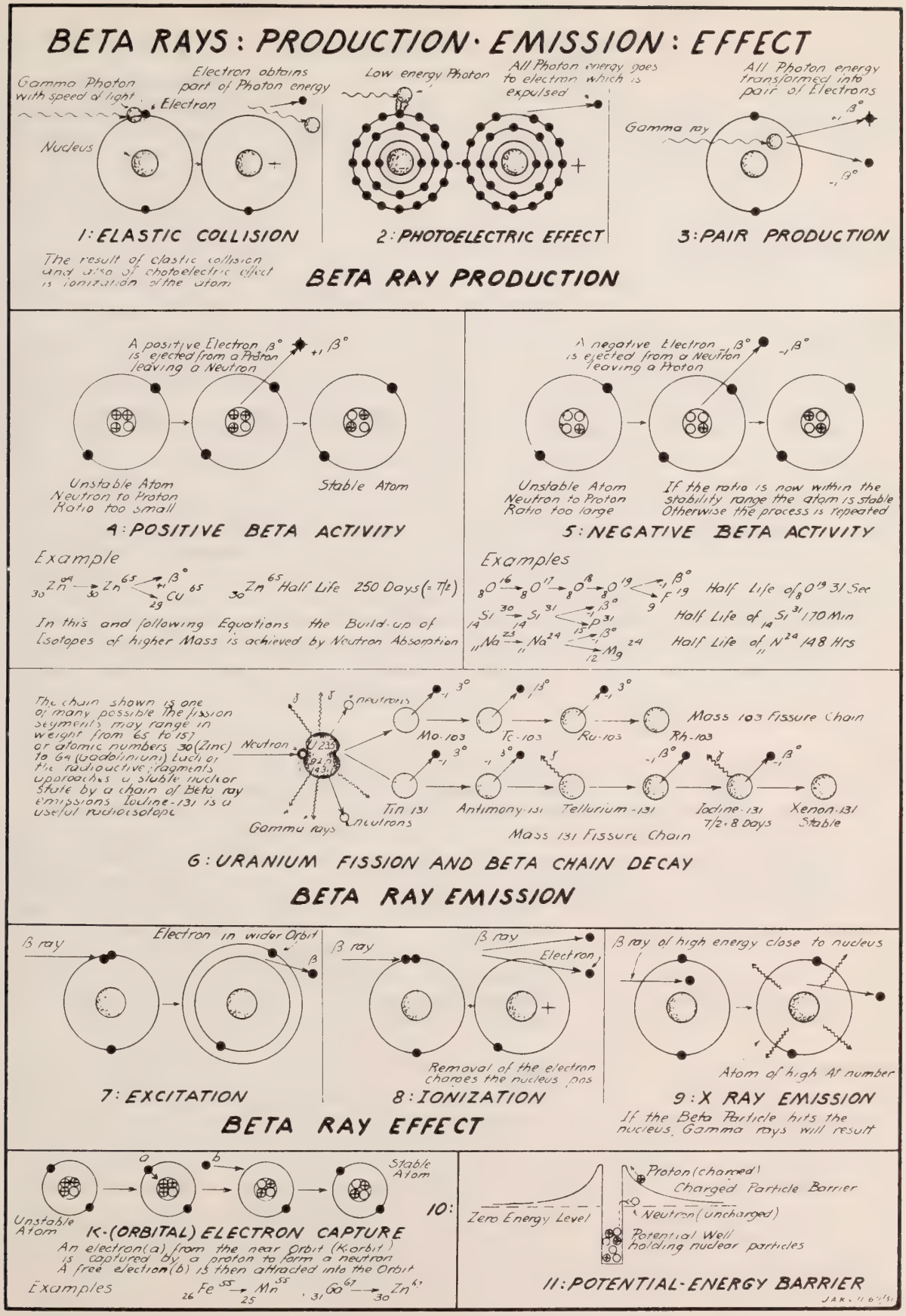
BETA RAYS: PRODUCTION · EMISSION : EFFECT
Gamma Photon with speed of light
Electron obtains part of Photon energy
Electron
Nucleus
1: ELASTIC COLLISION
Low energy Photon
All Photon energy goes to electron which is expulsed
2: PHOTOELECTRIC EFFECT
All Photon energy transformed into pair of Electrons
Gamma ray
3: PAIR PRODUCTION
The result of elastic collision and also of photoelectric effect is ionization of the atom
BETA RAY PRODUCTION
A positive Electron is ejected from a Proton leaving a Neutron
Unstable Atom Neutron to Proton Ratio too small
Stable Atom
4: POSITIVE BETA ACTIVITY
Example
Zn 65 Half Life 250 Days (= T/2)
In this and following Equations the Build-up of Isotopes of higher Mass is achieved by Neutron Absorption
A negative Electron is ejected from a Neutron leaving a Proton
Unstable Atom Neutron to Proton Ratio too large
If the ratio is now within the stability range the atom is stable Otherwise the process is repeated
5: NEGATIVE BETA ACTIVITY
Examples
Half Life of O 19 31 Sec
Half Life of Si 31 170 Min
Half Life of N 24 148 Hrs
The chain shown is one of many possible The fission segments may range in weight from 65 to 157 or atomic numbers 30 (Zinc) to 64 (Gadolinium) Each of the radioactive fragments approaches a stable nuclear state by a chain of Beta ray emissions Iodine-131 is a useful radioisotope
Neutron
Gamma rays
Neutrons
Mo-103
Tc-103
Ru-103
Rh-103
Mass 103 Fissure Chain
Tin 131
Antimony-131
Tellurium-131
Iodine-131 T/2 · 8 Days
Xenon-131 Stable
Mass 131 Fissure Chain
6: URANIUM FISSION AND BETA CHAIN DECAY
BETA RAY EMISSION
β ray
Electron in wider Orbit
7: EXCITATION
Removal of the electron changes the nucleus pos
8: IONIZATION
β ray of high energy close to nucleus
Atom of high At number
9: X RAY EMISSION
If the Beta Particle hits the nucleus, Gamma rays will result
BETA RAY EFFECT
Unstable Atom
Stable Atom
10: K-(ORBITAL) ELECTRON CAPTURE
An electron(a) from the near Orbit (K orbit) is captured by a proton to form a neutron A free electron(b) is then attracted into the Orbit
Examples
Fe 55 → Mn 55
Ga 67 → Zn 67
Zero Energy Level
Proton (charged)
Charged Particle Barrier
Neutron (uncharged)
Potential Well holding nuclear particles
11: POTENTIAL-ENERGY BARRIER

Fig. 5 Beta Rays: Production: Emission: Effect

Table 2. Particles Involved in Atomic Reaction

Particle	Mass	Electric Charge	Remarks
Electron	0	-1	Same as beta rays
Positron	practic . 0	+1	Not used yet
Proton	1	+1	Same as hydrogen nucleus
Neutron	1	0	Same as hydrogen atom in mass and charge
Deuteron {1 prot. 1 neut.	2	+ 1	Same as heavy hydrogen ion
Alpha particle {2 prot. 2 neut.	4	+ 2	Same as Helium nucleus
Beta rays			See electron
Gamma Rays	0	0	Bundles of energy

Alpha Particle Emission. Among the heaviest atomic species found in nature, there are those, such as uranium, thorium, and radium, which have no stable isotopes. There are about 30 radioactive isotopes of such elements occuring naturally. There also exists in nature about 20 radioactive isotopes of certain stable elements such as bismuth, lead, and potassium. For the heaviest radioactive isotopes (and very few of the isotopes of moderate atomic weight,) their instability can be adjusted in the direction of stability by the ejection of an alpha particle. The alpha particle carries a positive electrical charge, is composed of 2 protons and 2 neutrons like the helium nucleus, and travels with a speed of about 20, 000 miles per second. When it leaves the disintegrating atom, it picks up two electrons and becomes an atom of helium. Example: An atom of naturally radioactive substance such as uranium, or thorium, or radium may emit a positively charged particle which changes the atom to one of lower atomic number, i. e., an atom of thorium-232 (having 90 protons) emits an alpha particles, going through a series of transmutations until it changes into an atom of lead-208 (having 82 protons); each alpha particle picks up 2 electrons and becomes an atom of helium. (See Fig. 6-5 and 10)

Isotopes

Those who have taken an interest in reading about the atomic bomb know that the isotope, uranium-235, is one of the main explosive isotopes used in the production of the bomb. As previously stated, isotopes are atoms of the same element but which have different weights, although the number of protons in the atoms of any one element is always the same. In the case of uranium, no matter which isotope we consider, each atom has exactly the same number of protons, namely 92. There is one kind of uranium whose mass number is 234, another kind with 235, another 238, and still another with 239. Since each has exactly 92 protons, the weight difference can be accounted for only by differences in the number of neutrons. The uranium-238 has 146 neutrons in its nucleus, whereas the explosive isotope, the uranium-235, has three fewer neutrons. Almost every chemical element has atoms of different weight, i. e., has various isotopes. The atoms which have fewer neutrons in their nuclei are called the light isotopes of the element, and those with the most neutrons, the heavy isotopes.

When it was found that the rare isotope, uranium-235, was subject to fission or splitting and therefore amenable for use in the production of materials and development of techniques for releasing atomic energy, it became a major task to separate it from the more plentiful uranium -238. The separation of isotopes whose atomic weights are below 40 may be accomplished by the simple techniques of distillation, thermal diffusion, or centrifugation. But the problem becomes much more difficult where we are dealing with a mixture of atoms of the same chemical element whose differences in mass are relatively small. In such cases two other much more elaborate methods of separation are available, namely, the electromagnetic method, and the method of diffusion through porous material. In the former method, the uranium atoms are given an electrical charge and the stream of these electrified atoms is shot between the poles of a powerful magnet. The greater inertia of the uranium-238 causes it to resist the pull of magnetism more than the lighter uranium-235, hence the two isotopes become separated. On the other hand, the diffusion method depends on the rate at which gaseous molecules flow through porous materials. In this way the lighter uranium-235 atoms diffuse more rapidly than the heavier uranium-238 through the

porous material. The separation is very small and therefore requires that the process be repeated thousands of times. This requires mammoth size separation plants.

Nuclear Transformations

In addition to spontaneous radioactive decay resulting in the transformation of elements, and which cannot be influences in any practical manner, there are many other kinds of nuclear reactions brought about deliberately which are capable of inducing transformations. These are:

Neutron induced reactions.

1. Simple neutron capture. (See Fig. 6-1) The elements being bombarded with neutrons will produce heavier isotopes. They are usually radioactive and some products are useful as "tracer" elements:

$$_{45}Ag^{107} + {}_{0}n^{1} \rightarrow {}_{45}Ag^{108}$$

This reaction happens when a person with silver coins in his pocket steps near a cyclotron.[18] The neutron's energy must not be too high or too low.

2. Neutron Capture with Particle Emission. (See Fig. 6-2)

$$_{5}B^{10} + {}_{0}n^{1} \rightarrow {}_{3}Li^{7} + {}_{2}He^{4}$$

Here Boron -10 is transformed to Lithium-7 with the emission of an alpha particle. The illustration gives the change from phosphorus into silicon with the emission of a proton. Uranium is transmuted into plutonium by the following changes:

$$_{92}U^{238} + {}_{0}n^{1} \rightarrow {}_{92}U^{239} + \text{gamma ray}$$

$$_{92}U^{239} \rightarrow \beta + {}_{93}Np^{239}$$

$$_{93}Np^{239} \rightarrow \beta + {}_{94}Pu^{239}$$

Deuterons induced reactions.

Deuterons - a combination of proton and neutron, present in heavy water, can easier be obtained than neutrons and are the most widely used for the manufacture of radioactive elements. (A deuteron might be called a hydrogen isotope $_{1}H^{2}$.)

1. Proton emitted: (See Fig. 6-3)

$$_{15}P^{31} + {}_{1}H^{2} \rightarrow {}_{15}P^{32} + {}_{1}H^{1}$$

2. Neutron emitted: (See Fig. 6-4)

In these reactions both atomic numbers will be changed:

$$_{3}Li^{7} + {}_{1}H^{2} \rightarrow {}_{4}Be^{8} + {}_{0}n^{1}$$

This, as well as the beryllium-boron reaction illustrated, is good source of neutrons.

3. Alpha particles emitted (See Fig. 6-5)

$$_{13}Al^{27} + {}_{1}H^{2} \rightarrow {}_{12}Mg^{25} + {}_{2}He^{4}$$

These reactions take place with low yield.

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18. A cyclotron is an apparatus which, by means of a very powerful electromagnetic field, is capable of accelerating slower moving radiation particles so that they approach the speed of light and are thereby capable of producing artificial radioactive isotopes.

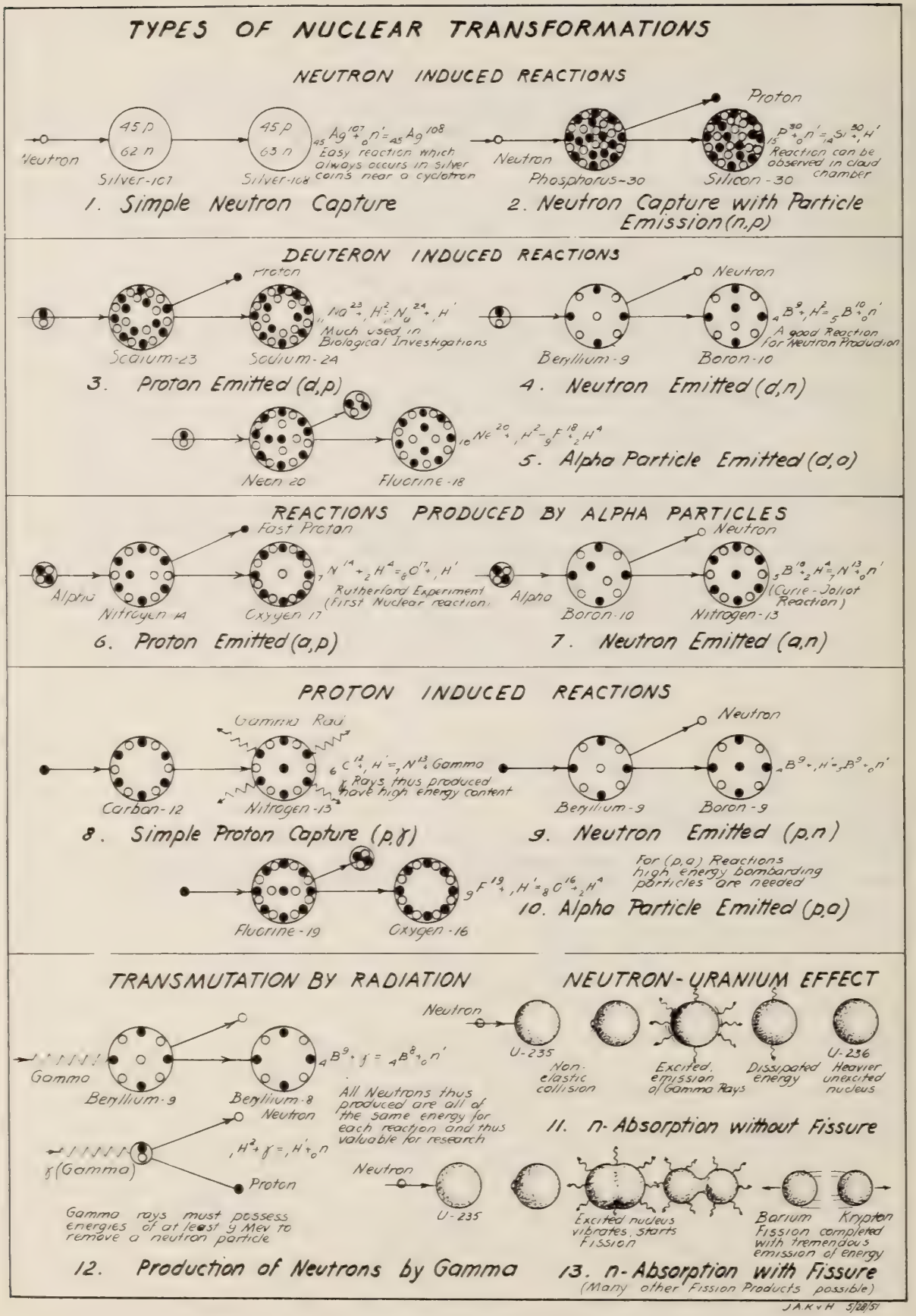


Fig. 6 Types of Nuclear Transformations

Reactions produced by alpha particles.

1. Proton emitted (See Fig. 6-6)

$$_{13}Al^{27} + {}_{2}He^{4} \rightarrow {}_{14}Si^{30} + {}_{1}H^{1}$$

(See also the formula of the Rutherford experiment, which changed Nitrogen 14 into oxygen 17, and which was the first nuclear reaction. Fig. 2).

2. Neutron emitted (See Fig. 6-7)

$$_{5}B^{10} + {}_{2}He^{4} \rightarrow {}_{7}N^{13} + {}_{0}n^{1}$$

(Curie - Joliot reaction)

Proton Induced Reactions.

These reactions are important because of the fact that protons can be obtained in large quantities and easily accelerated to about any desired velocity.

Simple proton capture. (See Fig. 6-8) Two cases are possible: the energy of the proton is equal or greater than the activation energy of the bombarded nucleus, or less than the activation energy but equal to one of several precise quantities producing a so-called resonant capture. The latter reactions produce gamma rays of a high frequency, therefore, of a high energy content, being from two to six times as energetic as any which can be obtained from the disintegration of natural substances. An example of a simple proton capture is:

$$_{6}C^{12} + {}_{1}H^{1} \rightarrow {}_{7}N^{13} + \text{gamma rays}$$

Neutron emitted (See Fig. 6-9) In this reaction a neutron in the nucleus is exchanged for a proton. As the emitted neutron is slightly heavier than the incoming proton, and as the lower n/p ratio makes the nucleus less stable than the original nucleus, an energy output into the nucleus is necessarily supplied by the kinetic energy of the moving proton. These reactions, therefore,form unstable elements which decay with the emission of positrons or electrons.

An example of the reaction is:

$$_{8}O^{18} + {}_{1}H^{1} \rightarrow {}_{9}F^{18} + {}_{0}n^{1}$$

The fluorine decomposes with a half-life of 112 minutes. Another reaction:

$$_{4}Be^{9} + {}_{1}H^{1} \rightarrow {}_{5}B^{9} + {}_{0}n^{1}$$ is shown in the illustration.

Alpha Particle emitted (See Fig. 222-10) Both the incoming and outgoing particles are charged; there are considerable electrical and potential energy barriers which must be overcome and the reaction is a difficult one using only high-energy bombarding particles:

$$_{9}F^{19} + {}_{1}H^{1} \rightarrow {}_{8}O^{16} + {}_{2}He^{4}$$

Transmutation by Radiation (Gamma rays) (See Fig. 6-12)

In this process all of the energy for rupturing the nucleus must be supplied as the electromagnetic energy of the gamma rays; this energy should be at least 9 Mev to remove a nuclear particle. The greater the energy of the wave, the shorter the wave length. Gamma rays emitted by natural substances are below this threshold value for most reactions, but a deuteron can be split into a proton and a neutron, and beryllium-9 can be reduced to beryllium-8 plus a neutron (see illustration.)

Neutron - Uranium effect. (See Fig. 6-11 and 13)

When uranium-235 absorbs a neutron by non-elastic collision, fission may or may not take place. In the first case (Fig. 6-11) the nucleus starts vibrating and under emission of gamma ray energy starts dividing into fission products such as barium and krypton; in the second case (Fig. 6-13) the nucleus is excited and gradually, by emission of gamma rays, settles down as an unexcited, heavier nucleus.

Half-life of Isotopes

Radioactive substances progressively decay by emitting various types of radiation. Uranium appears to be the parent element of all radioactive substances. The subjection of ordinarily stable materials to the bombardment from radioactive materials will produce unstable isotopes with

radioactive properties some of which can be and are being used for research and other purposes in such fields as medical therapy, animal physiology, chemistry, physics, plant physiology, industry, bacteriology, and metallurgy. The life of an isotope may be from a few seconds to millions of years. Regardless of the number of steps or the relative rapidity with which a nucleus achieves final stability, it shows no chemical or physical differences from its isotopes during the period between creation and disintegration except those due to the mass difference. The theory of radioactive decay assumes only:

a) That the lifetime of an unstable nucleus may have any value from zero to infinity.
b) That the rate of decay is independent of the previous length of life of the nucleus.

The lifetime of a given atom thus may be expressed only as a probability which has no practical significance except when large numbers of atoms are being considered. As is true of such purely statistical phenomena, the accuracy of prediction goes up with the increased number of cases, and since one normally deals with large numbers of atoms, it is possible to state the "half-life" of a given radioactive species quite accurately. The necessity for dealing in terms of half-life arises as a natural consequence of the fact that some of the atoms in a given sample of radioactive element may live forever. However, the half-life, by which is meant that time during which half of the atoms in a given sample will have decayed, is finite for all elements in which radioactive decomposition can be detected. If the half-life of radium be 1,590 years, then at the end of 1,590 years its half-life will be 1/2 of 1,590 or 795 years; then at the end of 795 years its half-life will be 1/2 of 795 or 397.5 years; then at the end of that period, its half-life will be 1/2 of 397.5 years, etc., ad infinitum. Thus, after 5 times the half-life, the activity will have fallen to about 3% of the original amount, and after 10 times the half-life period, the activity will have been reduced to only 0.1% of the initial value. Hence, after the lapse of sufficient time, decay may be regarded as virtually complete.

Table 3. Half-lives and Types of Radiation Activity of Some Radioisotopes

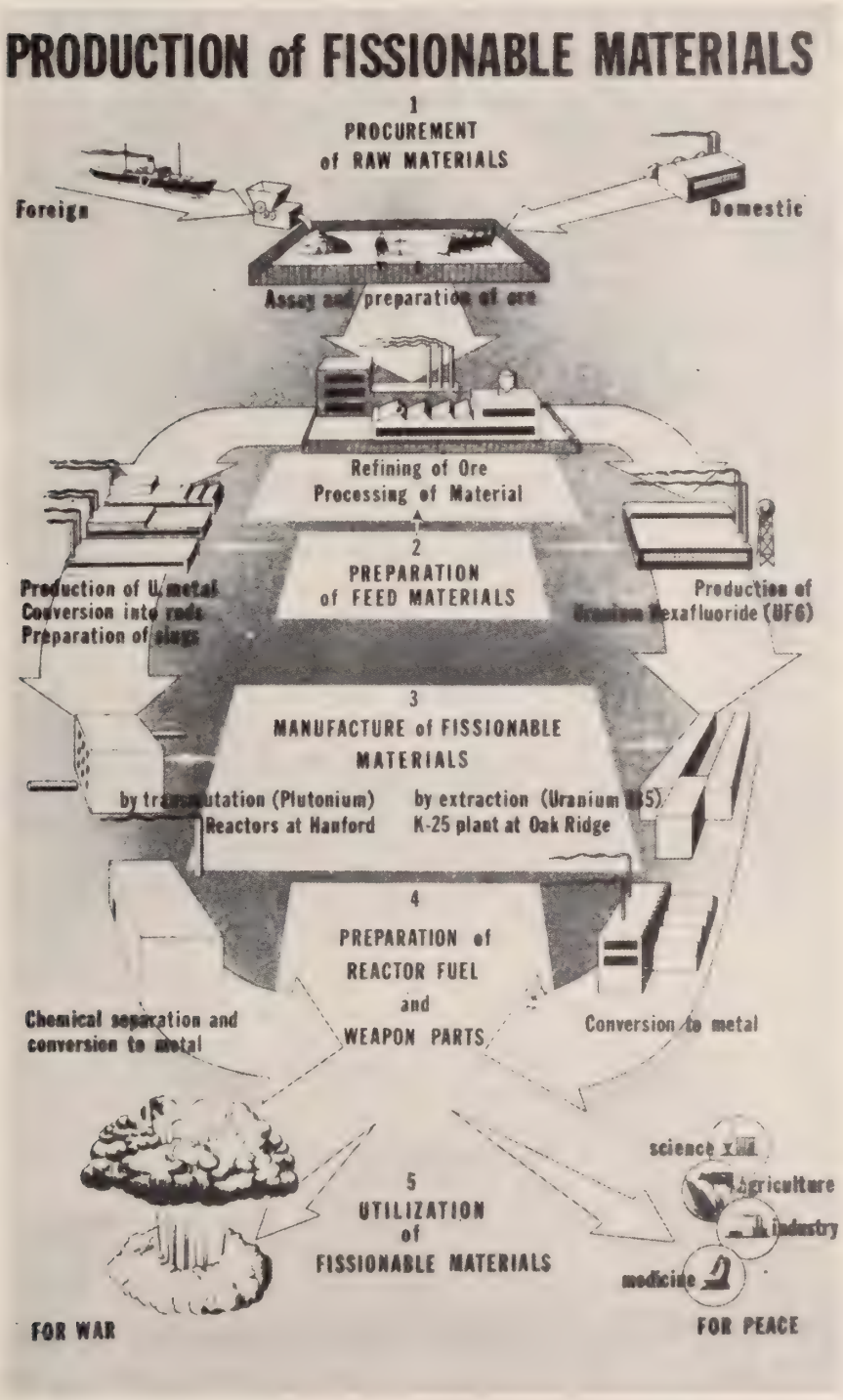
Isotope	Activity	Half-life	Isotope	Activity	Half-life
11-Sodium-24	β^-, γ	14.9 hrs.	92-Uranium-234	α, γ	2.48×10^5 yrs.
19-Potassium-40	β^-, β^+, γ K,	1.4×10^9 yrs.	92-Uranium-235	α	7.1×10^8 yrs.
34-Selenium-81	e^- β^-	59 mins. → 17 mins.	92-Uranium-238	α, γ	4.498×10^9 yrs.
35-Bromine-87	β^-, γ, η	55.6 secs.	92-Uranium 239	β^-, γ	23.5 mins.
36-Krypton-92	β^-	2.4 secs.	93-Neptunium-237	α, γ	2.2×10^6 yrs.
38-Strontium-89	β^-	54 days	93-Neptunium-239	β^-, γ	2.3 days
38-Strontium-90	β^-	25 yrs.	94-Plutonium-238	α γ	92 yrs.
39-Yttrium-93	β , γ,	10 hrs.	94-Plutonium-239	α, γ	2.41×10^4 yrs.
42-Molybdenum-93	γ, e^-, K	6.7 hrs. → 2 yrs.	94-Plutonium-240	α	6.58×10^3 yrs.
43-Technetium-99	β^-, γ, e^-	5.9 hrs. → 5×10^5 yrs.	94-Plutonium-241	α, β ,	14 yrs.
44-Ruthenium-106	β^-	1 yr.	94-Plutonium-242	α	5×10^5 yrs.
53-Iodine-131	β^-, γ,	8 days	95-Americium-241	α, γ	475 years
55-Cesium-137	β^-, γ,	33 yrs.	95-Americium-243	α	$\sim 10^4$ yrs.
58-Cerium-144	α β^-	290 days	96-Curium-243	α	35 yrs.
84-Polonium-212	α	3×10^{-7} sec.	96-Curium-244	α	19 yrs.
88-Radium-226	α, γ	1,620 yrs.	96-Curium-245	α	2×10^4 yrs.
89-Actinium-227	α, β^-, γ	27.7 yrs.	96-Curium-246	α	3×10^3 yrs.
90-Thorium-230	α, γ	8×10^4 yrs.	98-Californium-249	α	4.7×10^2 yrs.
90-Thorium 232	α, γ	1.39×10^{10} yrs.	98-Californium-250	α	12 yrs.
91-Protactinium-231	α, γ	3.43×10^4 yrs.			

Fission of Uranium and Plutonium

When uranium-235 or plutonium undergoes fission by slow neutrons, 89% of the energy is liberated in the first second (of which 83% is kinetic energy, 3% is gamma rays, and 3% is neutron energy.) The remaining 11% is set free later by the decay process of beta and gamma ray emissions. Fast neutron fission as in an atomic bomb explosion gives a somewhat different distribution of energy, but the principle is the same. In the latter circumstances the atoms actually split up in 30 or 40 different ways, and more than 60 primary products have been detected. The

19. β^- or β^+ refers to beta radiation, and "a" refers to alpha radiation.

Chart 3 Flow Chart of Production of Fissionable Material



range of the mass numbers of the products have been found to range from about 72 (probably an isotope of zinc) to 158 (believed to be an isotope of europium.) About 97% of uranium-235 which undergoes fission yields products which fall into two groups:

1) Light isotope group.
2) Heavy isotope group.

The fission products will have proton-to-neutron ratios greater than that which is understood to be within the range of stability for the particular elements, therefore they will be unstable and will exhibit both negative beta and gamma activity until they reach a stable stage. At the end of an hour, the radioactivity after an atomic explosion will be reduced by 95%; at the end of a day, the activity will be reduced by 99. 9%.

Basic Operations of the Atomic Energy Industry (See flow-chart (Chart 3 of operations)

With the basic knowledge of the structure and dynamics of the atom, it is also necessary to have a general picture of some of the basic operations of the atomic energy industry in order to grasp a relational perspective of the problems involved. Such a general picture involves no secretive information and gives the health worker an instrument for understanding the health hazards involved, —hazards which are in the order of normal industrial hazards where raw materials are processed and feed materials are produced, and also the special hazards entailed.

Because the yield of fissionable material* is very small as compared to the amounts used of source material*, and because of the difficulty in separating the fissionable from the source materials, and because of the tremendous heat generated in the production process, therefore, the number and size of the processing units are much greater than that of other industries, and the amount of hazard producing waste materials that may finally reach the ground, streams, and atmosphere is enormous.

The production of fissionable material is composed of two basic processes:

1) Isotope separation, i.e., separation of uranium-235 from uranium-238.
2) Nuclear transmutation, i.e., the transformation of uranium-238 into plutonium.

The principles upon which these two production processes are based are very different, but each process begins with the use of the same material, namely, large quantities of extremely pure natural uranium. The latter is called "feed material." The feed material for isotope separation is in the form of a gas, and that for nuclear transmutation is in the form of metal.

Production of Feed Material

The feed material is produced from source materials (uranium ore being the principle one) obtained in various parts of the world. These raw materials must be dried, crushed, ground, weighed, sampled, packaged, chemically analyzed, and stored. Analytic tests establish the uranium content of each batch of ore and these must be very exact. The next step in the production of the purified feed materials is accomplished by a series of complex chemical reactions to separate the impurities from the uranium. The result is a highly purified, uranium oxide (UO_2), a powder called "brown oxide." The brown oxide is then converted into uranium tetrafluoride (UF_4), a green salt. This stage involves a novel industrial chemical process. The resulting feed material is now used for either the isotope separation process, or the nuclear transmutation process. If used in the former process it must be converted into uranium hexafluoride (UF_6) which, at somewhat elevated temperatures becomes a gas. If used in the nuclear transmutation process, the feed material must be converted into extremely pure uranium metal, and made into slugs of suitable size and shape to be used in reactors.

Production methods are designed to reduce to a minimum any losses of uranium. But some loss is inevitable. Hence it has been necessary to develop a system of salvage for various process sludges, fluids, concentrates, dusts, dross, slags, and sweepings. Waste is recovered at all steps in the production process. A reasonable amount of recovery is possible by recycling certain materials through the various steps in the main production process. There are some forms of scrap material, however, which are not suited for recycling, and these must be shipped to plants where they are converted to a form suitable for return to the process.

Isotope Separation

The extracting of the 0.7% of pure uranium-235 which is contained in the ordinary uranium is a tedious job since there is a complete identity of all physical and chemical properties in uranium-235 and uranium-238 except for the slight difference in mass. The methods used for separation are:

a) The Electromagnetic Method. In this method the poles of an electromagnet are enclosed in a large vacuum chamber. Uranium is introduced in the form of a volatile compound. It is broken down and the uranium atoms are ionized. The ions are caused to move in circular paths by the ordinary electrodynamic action of a magnetic field. Since the light ions move in a path of slightly smaller radius than the heavy ions, the lighter isotopes separate out from the heavier ones. This sounds simple but it is a very tedious and exacting process.

*See definitions

b) The Gaseous Diffusion Method. According to accepted physical law, the molecules of a gas are in continual motion and the kinetic energy (i.e., the energy that a body has by virtue of its motion) is constant for all gases at the same temperature. The energy (K) is expressed in terms of the mass or weight (M) of the molecule, and the velocity (V) of its motion in the formula $K = 1/2\ MV^2$. In a gas which is a mixture of two isotopes such as uranium-235 and uranium-238, the lighter isotope molecules will travel at a higher velocity than the heavier molecules. If the mixture be confined in a box, these lighter, faster-moving molecules will strike the sides more often than the heavier molecules. Thus, if the side walls had holes just large enough to allow passage of the molecules, more of the lighter molecules would escape from the box. This principle is applied in the gaseous diffusion process. The gaseous uranium compound, uranium hexafluoride (UF_6) is permitted to come into contact with a porous "barrier." Because the uranium -235 molecules are lighter than the uranium-238 molecules, more of the former will pass through than the latter. Because the separation is only slight, many successive fractionations are necessary; and because of the need for large quantity separation, the total area of porous barrier in a plant is measured in square miles. This porous barrier is probably unlike anything ever before devised by man. It must contain billions of holes per square in., each one a few ten-millionths of an inch in diameter. It must be very thin and therefore fragile, and yet must withstand a considerable pressure. There are many difficult engineering problems involved in this method, one reason beside the character of barrier, being the extreme corrosiveness of uranium hexafluoride.

c) The Thermal-Diffusion Method. This method is based on the application of a curious and little understood physical phenomenon occurring in liquids and gases whereby a mixture of gases or mutually soluble liquids when put into a container of which one part is hot and one part cold, the denser material will, after a long time, be pulled to the cold side and the lighter material to the hot side. This process has proved less efficient than the others and has been discontinued.

Plutonium Production

Plutonium is produced by exposing uranium-238 to neutron bombardment in a pile or reactor, as already indicated, whereby the non-fissionable uranium-238 is transformed, in various stages, into fissionable plutonium. This process requires enormous quantities of water or air to keep the pile cool from the heat generated by the chain reaction in the pile. The operation of the pile is a complicated technique requiring high standards of reliability and accuracy, and the performance of many operations by remote control. Plutonium production plants produce the largest quantity of radioactive waste having the greatest degree of radioactivity.

The separation of the plutonium from the uranium, unlike the separation of uranium-235 from uranium-238, is a fairly simple chemical technique, since the two chemicals are entirely dissimilar elements. Although the technique is relatively simple, the size and design of the plant is novel. These plants are, essentially, long deep canyons of concrete containing processing cells within which the necessary series of chemical operations can be carried on behind heavy shielding and by remote control. (The amount of concrete that is used for such a canyon is approximately 90,000 cubic yards, or enough for 30 miles of highway.) The sludge of uranium is intensely radioactive. Personnel handling them remain behind heavy shields several feet thick and view the work through periscopes.

Excess contamination of the cooling water may occur from various technical breaks. Slugs from a pile are stored in the underground for several months to allow short half-life materials to dissipate before being processed chemically. The processing of a slug requires dissolving, precipitating, washing, and re-precipitating. Accidental spills in chemical processing occur in safe manners since operations are carried on in highly shielded cells. The flushing of cells and the changing of equipment can be done by remote control. The drains from cells, in case of spillage, go to storage tanks.

The most successful method of control of contamination occasioned by chemical operations is to confine the contamination as much as possible so that the removal of contaminants takes place from the smallest possible volume of air or water near the source.

After the plutonium has been extracted from the slugs, the remaining uranium, containing highly radioactive fission products, is held in storage.

The metallurgical and chemical processes required for production of fissionable materials produce various types of wastes containing radioactive substances against which the workers and the community must be protected. The wastes, for example, may be:

1) The ore from which uranium has been extracted.
2) The dusts, vapors, fumes and gasses.
3) The air and water used in cooling the reactors.
4) The liquid and solid wastes from the chemical processes.
5) The equipment, instruments, glassware, etc.
6) The buildings which have become contaminated.

Definitions

Angstrom = one-hundred millionth of a centimeter.

Bev = billion electron volts

By-product material is any radioactive material (except fissionable material) yielded in or made radioactive by exposure to the radiation incident to the processes of producing or utilizing fissionable material.

Carrier is a vehicle material (macrocomponent) used to carry minute quantities of radioactive substances (microcomponent) through chemical procedures when these minute quantities are too small to be handled expediently. The most effective carrier is a material which is an isotope of the radioisotope itself. The latter is called "isotopic" carrier. When a carrier is added to prevent the precipitation of the microcomponent on a macrocomponent, it is termed "holdback carrier".

Curie (c) is the unit of measure of radioactivity. It is the amount of radioactive material that disintegrates at the rate of 37 billion disintegrations per second.

mc = millicurie, or 1/1000 curie

μc = microcurie, or 1/1,000,000 curie

Cyclotron is a device for accelerating charged particles to high energies by giving successive increments from an alternating electric field between electrodes placed in a constant magnetic field.

Dosimeter is an instrument used to detect and measure an accumulated dosage of radiation.

Dyne = a force which, acting on a mass of one gram for one second, will change its velocity by one centimeter per second.

Electron-volt = the amount of energy acquired by an electron when the potential drops 1 volt. In terms of the erg, the relation is:

$$1 \text{ electron volt} = 1.60 \times 10^{-12} \text{ erg.}$$

$$(10^{-12} = \frac{1}{1,000,000,000,000} \text{ just as } 10^{12} = 1,000,000,000,000)$$

Electroscope is an instrument for detecting the presence of electric charges by the divergence of charged bodies (usually gold leaves).

Energy is defined in physics as a capacity for doing work. It appears in many forms, as energy of motion or kinetic energy, gravitational energy, heat energy, chemical energy, nuclear or atomic energy, and so on. But it is always measured by the work which it does, i.e., as the product of the amount of force exerted multiplied by the distance through which the force acts: Energy = Force x Distance.

Since the erg is the fundamental unit of energy of the metric system, all the other units are based on the erg:

Energy Unit	Equivalent in ergs
Erg	1.00
Electron-volt (ev)	1.60×10^{-12}
Foot-pound	13.56 million
Gram-calorie	41.86 "
British thermal unit (B.T.U.)	1.05×10^{10}
Horsepower-hour	2.68×10^{13}
Kilowatt-hour (1.341 horsepower-hours)	3.60×10^{13}

Erg = the work done when a body moves one centimeter in the direction in which it is urged by a force of one dyne.

Esu = electrostatic unit, or $\frac{1}{3 \times 10^9}$ coulombs, or 2.083×10^9 ion pairs.

Fissionable material is plutonium, uranium-235 or any other material capable of releasing substantial quantities of energy through nuclear chain reaction.

Fluorescence is the emission of electromagnetic radiation by a substance as the result of an absorption of energy from some other radiation, either electromagnetic or corpuscular, and characterized by the fact that it occurs only so long as the stimulus responsible for it is maintained.

Fluorescent screen is a sheet of material coated with a fluorescent substance emitting visible light when irradiated with ionizing radiation.

Gieger-Mueller counter is a highly sensitive gas-filled radiation-measuring device which operates at voltages above the geiger threshold and below the voltage at which complete gaseous break-down would occur.

Hard radiation has the characteristics of short wave lengths, high energy, and high penetrating power.

Ion is an atom or group of atoms (a radical) that acts as a chemical unit and that carries an electric charge.

Ionization is the process by which a neutral atom or molecule acquires either a positive or negative charge.

Ionizing radiation is any radiating particle or electromagnetic wave that has the property of producing ions in passing through any substance; it includes alpha and beta particles, neutrons, x-rays, and gamma rays.

Ion chamber is a container of gas in which an electric field exists because of a system of charged electrodes.

Ion-pair is the electron and the ion that is formed when a charged particle passing close enough to an atom or molecule has sufficient force to remove an electron and therefore to ionize the atom or molecule.

Kv = kilovolt or 1000 volts.

Mev = million electron volts.

Nuclide is a species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons Z, the number of neutrons N, and energy content; or, alternately, by the atomic number Z, mass number A (= N + Z), and atomic mass.

Pair production is the result of the passing of a gamma ray near the nucleus of an atom and the conversion of the gamma ray into a positive and negative electron, (Fig. 5 - 3) both of high energy. The opposite is called annihilation radiation.

Parent is a radionuclide that, upon disintegration, yields a specified nuclide, the daughter, either directly or as a later member of a radioactive series. Example: U^{238} is the parent of all members of the uranium series, including the end product, Pb^{206}. Daughter is a nuclide formed in the radioactive decay of another (called the parent). A synonym for decay product.

Photon is a bundle of electromagnetic radiation acting just like a material particle.

Rad is one hundred ergs of absorbed energy per gram of absorbing material.

Radionuclide is a synonym for radioactive nuclide.

Roentgen, r is the quantity of x- or gamma radiation such that the associated corpuscular emission per 0.001293 grams of air produces, in air, ions carrying 1 esu of electricity of either sign. Associated corpuscular emission is the full complement of secondary charged particles (usually limited to electrons) associated with an x-ray or gamma ray beam in its passage through matter.

The Roentgen Equivalent Physical (rep) means the amount of ionizing radiation which is capable of producing 1.615×10^{12} ion pairs per gram of tissue or that will suffer an absorption in tissue of 83.8 ergs per gram.

The Roentgen Equivalent Man (rem) is that quantity of radiation which when absorbed by man produces an effect equivalent to the absorption by man of one roentgen of X or gamma radiation, i.e., it is the measurement of damage caused in tissue by one rep of gamma or X-rays.

One rep of another type of radiation, delivering an equivalent amount of energy, would create more rems of damage, than would one rep of gamma or X-rays as follows:

Gamma or X-rays	1 r	=	1 rep	=	1 rem
Beta particles			1 rep	=	1 rem
Protons, neutrons			1 rep	=	10 rem
Alpha particles			1 rep	=	20 rem

In general, 1 r is not equal to 1 rep, since the actual energy absorption in tissue per r is a function of the tissue composition and of the wave length of the radiation. It ranges between 60 and 100 ergs per gram.

mr = milliroentgen, or 1/1000 roentgen
μr = microroentgen, or 1/1,000,000 roentgen
mrep = milliroentgen equivalent physical, or 1/1000 rep.

Scintillation is a flash of light produced in a phosphor by an ionizing event.

Scintillation counter is the combination of phosphor, photomultiplier tube, and associated circuits for counting scintillations.

Soft radiation has the characteristics of long wave lengths, low energy, and low penetrating power.

Source material is uranium, thorium or ores containing these elements or any other material peculiarly essential to the production of fissionable materials.

Synchrotron is a device for accelerating particles, ordinarily electrons, in a circular orbit in an increasing magnetic field by means of an alternating electric field applied in synchronism with the orbital motion. A proton-synchrotron is a synchrotron modified to permit the acceleration of protons by frequency modulation of the radio frequency accelerating voltage.

The Effect of Radiation on Living Tissue

The biological effects of radiation are due primarily to a process called ionization. When any of the radiations, alpha, beta, gamma or neutrons impinge on matter, they create an electrical imbalance by knocking off or removing electrons from the outer electron shell surrounding the nucleus. The atom having lost a negative charge now becomes a positively charged ion, and together with the electron separated from it, they become an ion pair. While the end result of the interaction of radiation with matter is the formation of ions, there is a direct and an indirect way in which this is accomplished, depending on the type of radiation. For example, when the relatively heavy and energetic alpha particle plows into matter, it literally "scrapes" off electrons by the thousands. An alpha particle can produce from 40 to 80 thousand ion pairs in a centimeter of travel through a gas. In a solid or a liquid such as a cell, the alpha particle will travel only a fraction of a millimeter, but in that distance will still strip off enormous numbers of electrons. The beta particle, or electron acts similarly except that the effect is very much reduced, being of the order of less than 1% that for alpha particles. Thus, the alpha and beta particles ionize matter by the direct production of ion pairs. Gamma rays and neutrons on the other hand ionize matter indirectly. These radiations must first produce energetic particles out of the matter with which they react. These energetic particles, in turn, strip electrons off the atoms thereby producing ion pairs. When a gamma-ray photon passes close to the nucleus of an atom, —in this particular case, the atom of a living cell, —all the photon energy of the gamma-ray is transformed into a pair of fast-moving electrons, one with a negative charge and the other with a positive charge, each of which starts on its own path of movement. This is called "pair production" (See Fig. 5-3). These energetic secondary electrons interact with other electrons present in various atoms, causing ionization of the latter and frequently disrupting chemical bonds. It is the decomposition of certain molecules in living organisms, resulting from the breaking of chemical bonds which alters the characteristics of vital parts of cells and causes physiological damage.

When gamma rays are absorbed by matter, the resultant electrons which are ejected have sufficient energy to produce considerable ionization. Neutrons produce recoil protons from interaction with hydrogen or nitrogen (both of which exist in high concentration in biological matter.) The recoil protons behave similar to alpha particles, producing an intense and highly localized ionization.

It is very important at this point to state this thesis: The only damaging role that radiation plays in living tissue is ionization. Ionization is a result of absorption of radiation energy by matter. Energy which is not absorbed by living tissue is therefore harmless.

Ionization is qualitatively identical for all radiation but not quantitatively. The degree of ionization is determined by the type of particle or ray. The term specific ionization is used to express the quantitative difference in the ionizing capacities. Specific ionization is simply a measure of the number of ions produced per centimeter of air path by an ionizing radiation. Specific ionization varies directly with the square of the charge on the particle or ray, and inversely with its speed. Thus, the alpha particle having 2 charges and travelling at 1/10 the speed of light is more effective in producing ionization than the beta particle which carries but one charge and travels 9/10 as fast as light, and the high speed gamma photon has a specific ionization which is almost negligible when compared with the beta particle. On the other hand, the specific ionization of the neutron is very high, of the same order as the alpha particle, but this is because all neutron ionization is secondary, being produced by ejected protons which have a speed and behavior similar to alpha particles.

The damage to tissue is due to the absorptions of energy from the radiation, this absorption being reflected in ionization. The roentgen is the unit which is used. It is that quantity of X or gamma radiation producing 1.61×10^{12} ion pairs per gram of air. The roentgen does not depend upon the time required to produce this amount of ionization. The effect is considered instantaneous. The roentgen is actually a measure either of the quantity of ionization produced in air by the secondary electrons formed in gamma ray or X-ray collisions with air molecules, or a measure of the amount of energy absorption. The amount of energy absorption can be measured in ergs. 1 roentgen is equivalent to the absorption of 83.8 ergs by one gram of air. It cannot be used to measure the energy absorption of alphas, betas, or neutrons. The biological effects of various ionizing radiations depend among other things upon the density of ionization (specific ionization) along the path of the particle in tissue. Consequently, a greater amount of tissue damage

may be expected from a 1 Mev alpha than from a 1 Mev beta particle. However, the roentgen has a clinical interpretation because so many observations in terms of roentgens have been made of the effects of X-rays particularly. For this reason it is desirable to relate the ionization effects of particles to that of the photon or electromagnetic radiation, i.e., the X or gamma ray. Since 1 roentgen produces 1.61×10^{12} ion pairs per gram of air, then that absorption of either alpha or beta particles which produces the same number of ion pairs is for all practical purposes equivalent to 1 roentgen. This absorption of energy is defined as a roentgen-equivalent-physical, or rep. No confusion need result so long as we do not attempt to measure alpha or beta radiation with physical instruments calibrated in roentgens. If we do, the readings will have to be adjusted by appropriate factors which take into account the relatively high specific ionization of alphas and betas compared to gammas. Because energy absorption by tissue of alphas and neutrons is different from the absorption by air, a second derived roentgen has been developed. This is called the rem, or roentgen-equivalent-man. It is defined as that amount of radiation of any kind which produces a biological effect equivalent to that produced by 1 roentgen of X or gamma radiation. We can make a comparative scale of the various units and types of radiations. For X or gamma rays, 1 r = 1 rep = 1 rem. This assumes that the absorption of gamma rays in air and in tissue is the same. For beta rays, 1 rep = 1 rem. Again the assumption is made that the absorption of betas in air and in tissue is the same. For protons and fast neutrons, 1 rep = 10 rems, i.e., the absorption of 1 rep by tissue appears to produce 10 times the effect anticipated from air absorption. For alpha particles, 1 rep = 20 rems.

Chemical Changes. Despite the many experiments on the chemical effects of ionizing radiations, the exact mechanisms still remain to be elucidated. There is now a tendency to explain most of the biological effects of radiation by the actions of the decomposition products of water produced by these radiations. When water is irradiated there are produced H atoms and hydroxyl radicals, but these promptly recombine. However, the situation is radically changed if there be present in the water substances which can interact chemically with the H atoms and the hydroxyl radicals. For example, the H atoms can combine with dissolved oxygen to form hydrogen peroxide. Hydrogen peroxide has been shown to inactivate a number of enzyme systems by oxidizing the active sulfhydryl group which they contain. Hydrogen peroxide may therefore be regarded as a toxicant because it inactivates enzyme systems essential for the metabolism of the cell. It is significant that the hydrogen peroxide effect is reversible, provided the radiation dosage does not exceed 100 r. It is postulated that above this level the ionization produces, besides H_2O_2, denaturization of the protein moiety of the enzyme molecule. The latter is not reversible. There is evidence that radiation effects certain physical changes in cells. The most important is interference with the permeability of the membrane surrounding the cell. Such interference might result in hydration or desiccation, or the accumulation of toxic metabolites which are ordinarily disposed of by "leaking" out of the cell. Lastly, it is believed that changes or alterations in the cellular environment may occur either as direct or indirect effects of radiation. Examples might be pH or electrolyte changes. Some morphological changes in the cell are: (1) Breaks in chromosomes. (2) Clumping of the chromatin. (3) Changes in cell division with formation of giant cells or abnormal mitosis. (4) Changes in affinity for various stains. (5) Changes in motility of the cell. (6) Swelling of the nucleus or of the entire cell. In general, it is the nucleus of the cell which reacts to radiation, whereas the cytoplasm is not so sensitive.

Cellular Response. The most striking fact about cellular response to radiation is that it is variable and random. When radiation passes through a group of cells of the same type it may produce ionization in the nucleus of one cell, ionization in the cytoplasm of another cell, ionization in the cell wall of a third cell. All of these sites of action produce different effects. When many-celled organisms are irradiated the complexities are increased further due to the variability of response of cells of different types, and to the possibility that in such multicelled organisms radiation damage in one tissue may produce indirect effects on others.

Cellular Environment. Changes or alterations in the cellular environment, whether resulting from a radiation toxicant or from other causes may determine the degree of damage of ionizing radiation. For example, subjecting cells to cold or to freezing decreases radiosensitivity; so does anoxemia. On the other hand, a change from normal pH of intercellular fluids may predispose to increased radiosensitivity.

Sensitivity of Tissue. Different types of cells show remarkable variations in their response

to radiation. In general, it is the nucleus of the cell which reacts to radiation, whereas the cytoplasm is not so sensitive. Hence, a large cell with much cytoplasm, such as the giant amoeba is not greatly affected by radiation. Radiosensitivity may be classified on the basis of the ratio of nuclear substance to cytoplasmic substance. When this ratio tends toward unity radiosensitivity increases. This explains why a nerve cell with a very large preponderance of cytoplasm over nuclear substance is less radiosensitive while a white cell in which the reverse is true is more radiosensitive, and why rapidly multiplying or actively reproducing cells (large and active nuclei) are on the whole more radiosensitive than quiescent cells. This is the basis for the use of radiation in the treatment of certain tumors or malignancies. The rapidly growing tumor tissue suffers greater radiation damage than the surrounding normal tissue. Some of the common tissues of the body in the order of their decreasing radiosensitivity are: lymphoid tissue and bone marrow, polymorphonuclear leucocytes, gonads and ovaries; skin and mucous membrane, blood vessels, connective tissue, muscle cells, nerve cells.

Species Sensitivity. One of the peculiarities of radiation is the wide variation in response of different species to identical doses of radiation delivered under the same conditions. Such variation can be seen in the different values of the median lethal dose for animals exposed to 0.2 Mev X-ray: mice, 500 r; guinea pigs, 250 r; rabbits, 875 r. Such a large variability makes it almost impossible to transfer quantitative animal data to man.

Intensity of Radiation. In most instances the biological effect of a given dose decreases as the rate of exposure decreases. As the dose decreases the recovery processes in the tissue are enabled to repair the damage as fast or faster than it occurs. If, however, the intensity or rate of delivery of radiation be increased, recovery fails to keep up with damage and an increase in the effectiveness of the dose becomes apparent. It is this recovery factor or decreased ability of low intensity exposures to produce detectable damage, which is the basis for setting the tolerance value where it now is, that is, 60 mr/24 hours. However, some effects of radiation seem to be independent of the dosage rate. Such are cumulative or additive effects. In such instances, there is no capacity of the tissue for repairing damage, however, slight, so that each insult is "remembered" as it were, and adds itself to the last. Among such effects are genetic ones and the influence of radiation on the development of certain types of radiation tumors. In the cases cited the total dose rather than the rate is most important.

Clincial Manifestations. Tissue which has been damaged by radiation follows the same general rules as tissue damaged by other stimuli. Those tissues which are incapable of reproducing functional cells after destruction will not recover from radiation damage, such as muscle, brain, portions of the kidney and the eye.

In considering injuries to specific tissues, the most seriously affected are the blood forming organs. These are bone marrow and lymphoid tissue. In general, the shorter the life of a particular class of blood cells, the more quickly will it reveal evidence of radiation injury by a reduction in the number circulating in the blood. The lymphocytes are the shortest lived, and their number is reduced within a very short time after exposure to radiation; next come the granulocytes and the platelets, and finally the erythrocytes. These facts form a very important basis for evaluating the clinical symptoms that follow radiation, and give the physician a measuring instrument, the blood count, to make fairly reliable prognosis of the outcome. Following severe exposure to radiation there is always a decrease in the number of leucocytes starting with the lymphocytes. At present the white cell count is considered to be the most valuable and direct single index of radiation sickness.

In general, the lowering in count of white blood corpuscle comes within 7 days, that of the red blood corpuscles in 10 to 14 days after exposure. An array of clincial symptoms have been observed which are directly traceable to deficiencies in these important cells. Some of these are ulceration of the tonsils, mouth and throat, resulting from severe injury to lymphoid tissue; massive infections, resulting from the inability of the reduced force of white cells to cope with bacterial invasions; marked tendency to bleed, sometimes directly into some mucous cavity or organ, or under the skin, resulting from the loss of clotting ability of the blood due to lack of sufficient platelets; anemias, resulting from reduced number of red blood corpuscles.

The direct effect of radiation on the mucous linings of the gastrointestinal tract causes nausea and vomiting, and somewhat later, diarrhoea. Within a week there may be swelling, inflammation, hemorrhages and finally ulceration. The effects may be particularly severe in the small intestines where in addition to the mucous lining there are large concentrations of radiosensitive lymphoid tissue. Coupled with the primary effects of radiation on these mucous and lymphoid tissues are the secondary ones incident to lowered local resistance, and lowered efficiency of the defense mechanisms ordinarily supplied in the circulating blood. Temporary loss of hair is a common result of excessive radiation.

Body Tolerance of Radiation

It is known that the body has certain degrees of tolerance to various poisons. This is also true for tolerance to radioactivity. Knowledge of the amount of energy particles or radiations which the human system can tolerate with safety becomes an important factor in determining control procedures. Such knowledge has, in the past, been based mostly on medical and biological experience with the X-ray and with gamma radiation from radium. We know, for example, that if a group of people were given a single dose of gamma radiation of 450 r, about one half of the group would die. This would, therefore be the lethal dose for 50% of human beings and is expressed as LD-50. However, most individuals could take 450 r if it be given not in a single dose but in a series of small doses over a period of several months. If 5000 r be limited to an area of the skin 1/2" square, skin cancer may be cured, leaving only a scar and doing no harm to the individual. A diagnostic chest X-ray is equivalent to about 10 r. In setting a permissible limit, physicians incorporate a factor of safety of about 10; hence, 0.06 r* or 60 mr per day is the standard permissible limit for continuous exposure to gamma or X-ray. This applies to persons working in atomic energy installations and to physicians, nurses, and technicians working with X-ray. It has been reported that minute biological changes can be induced by exposures as low as 0.2 r per day over an extended period of time.

TABLE 4

SUMMARY OF EFFECTS RESULTING FROM ACUTE WHOLE BODY EXTERNAL EXPOSURE OF RADIATION TO MAN*

0-25 r	25-100 r	100-200 r	200-300 r	300-600 r	600 or more
No detactable clinical effects. Delayed effects may occur.	Slight transient reductions in lymphocytes and neutrophils. Disabling sickness not common, exposed individuals should be able to proceed with usual duties. Delayed effects possible, but serious effects on average individual very improbable.	Nausea and fatigue, with possible vomiting above 125 r. Reduction in lymphocytes and neutrophils with delayed recovery. Delayed effects may shorten life expectancy in the order of one per cent.	Nausea and vomiting on first day. Latent period up to two weeks or perhaps longer. Following latent period symptoms appear but are not severe: loss of appetite, and general malaise, sore throat, pallor, petecheae diarrhea, moderate emaciation. Recovery likely in about 3 months unless complicated by poor previous health, superimposed injuries or infections.	Nausea, vomiting and diarrhea in first few hours. Latent period with no definite symptoms, perhaps as long as one week. Epilation, loss of appetite, general malaise, and fever during second week, followed by hemorrhage, purpura, petecheae, inflammation of mouth and throat, diarrhea, and emaciation in the third week. Some deaths in 2 to 6 weeks. Possible eventual death to 50% of the exposed individuals for about 450 roentgens.	Nausea, vomiting and diarrhea in first few hours. Short latent period with no definite symptoms in some cases during first week. Diarrhea, hemorrhage, purpura, inflammation of mouth and throat, fever toward end of first week. Rapid emaciation and death as early as the second week with possible eventual death of up to 100% of exposed individuals.

*Adapted from "The Effects of Nuclear Weapons," U. S. Government Printing Office, 1957.

Table 5. Tolerance* or Maximum Permissible Exposure for External Total Body Radiation

Type of Radiation	mr/week	mrep/week	mrem/week
X-ray	300	300	300
Gamma rays	300	300	300
Beta particles		300	300
Neutrons		300	3,000
Protons		300	3,000
Alpha particles		300	6,000

*Tolerance levels calculated from information in Eighth Semiannual Report of the A.E.C. 1950, p. 11.

Table 6. Tentative Tolerance for Radioactive Materials Taken into Body through Food, Water, or Air, under Non-emergency Conditions

Intake Through	Microcuries	Disintegrations Per Second	Disintegrations Per Minute
Air	2×10^{-4} per cubic meter of air	7.4	440
Water in: Gravimetric Units	2×10^{-2} per liter	14.8	880
Radioactivity Units	4×10^{-3} per liter		
Food	Not to exceed one meal, a maximum level of 300 disintegrations per minute per square centimeter of surface		

Table 7. Emergency Levels of Radioactivity in Drinking Water in Period Immediately Following Nuclear Explosion

Time water is to be Consumed	Acceptable Beta-Gamma Activity		Acceptable Alpha Activity	
	Microcuries per c.c.	Disintegrations per minute per c.c.	Microcuries per c.c.	Disintegrations per minute per c.c.
10 days	9×10^{-2}	2×10^{5}	5×10^{-3}	1.1×10^{4}
1 month	3×10^{-2}	7×10^{4}	1.7×10^{-3}	3.7×10^{3}

In setting the tolerances for exposure in radiation, a sharp differentiation between internal and external exposure must be made. Whereas an external source can be removed or be moved away from or be shielded, these precautions cannot be taken when the source has been taken into the body through food, water, or air. The important characteristic of ingested material is that it tends to concentrate in certain portions of the body from which it is eliminated slowly. In order to describe this behavior, a quantity called the biological half-life has been introduced. This is defined as the period of time during which the amount of a particular radioactive element deposited in the body is reduced to half its initial value. The biological half-life of a given species depends on its ordinary radioactive half-life which determines the natural rate of decay, and also on the rate of its elimination from the body. An isotope with a very short radioactive half-life will inevitably have a short biological half-life, but for substances with moderate or long radioactive half-lives, the biological half-life may be long or short, depending on whether the particular isotope tends to be concentrated in the body or not.

In order to keep our perspective when dealing with radiation hazards, we must remember that we are continuously being bombarded by ionizing radiation in the form of cosmic rays. Those living in Baltimore or New York will get, in the course of their lives, about 2 r of cosmic rays. Those living in the Mountain States will get about ten times as much or perhaps 20 r. At least 4

radioactive materials are normally found in man in minute quantities (carbon-14, potassium-41, radium, and uranium).

According to present knowledge, the whole body exposure to gamma radiation must not exceed 300 mr per week. This general exposure to gamma radiation is believed to be safe as far as any bodily injury is concerned when there is no other type of radiation exposure. The importance of possible genetic change effective in later generations is open to question.

When the body is exposed to an external source of beta radiation, only the superficial layers up to a few millimeters in thickness are irradiated. Nevertheless, for safety, the limiting general exposure to external beta radiation should be taken as 300 mrep. per week in the surface layers. The outermost layer of skin is considered to be a dead hornified layer which acts as a filter, and the dose is computed for the zone immediately below this. The filter thickness is taken as 7 mg. per cm.^{2}, except on the palms, where it is about 40 mg. per cm^2.

Basic Standards of Maximum Permissible Radiation Exposure

The National Committee on Radiation Protection (NCRP) has formulated the four following basic rules and recommendations concerning exposure to ionizing radiation:

Basic Rules

1. Accumulated Dose (Radiation Workers)

a. External exposure to critical organs. Whole body, head and trunk, active blood-forming organs, eyes or gonads: The Maximum Permissible Dose (MPD) to the most critical organs, accumulated at any age, shall not exceed 5 rems multiplied by the number of years beyond age 18, and the dose in any 13 consecutive weeks shall not exceed 3 rems.

Thus the accumulated MPD = (N-18) x 5 rems where N is the age in years and is greater than 18.

Comment: This applies to radiation of sufficient penetrating power to affect a significant fraction of the critical tissue.

b. External exposure to other organs. Skin of whole body: MPD = 10 (N-18) rems, and the dose in any 13 consecutive weeks shall not exceed 6 rems.

Comment: This rule applies to radiation of low penetrating power.

Hands and forearms, feet and ankles: MPD - 75 rems/year, and the dose in any 13 consecutive weeks shall not exceed 25 rems.

c. Internal exposures: The permissible levels from internal emitters will be consistent as far as possible with the age-proration and dose principles above. Control of the internal dose will be achieved by limiting the body burden of radioisotopes. This will generally be accomplished by control of the average concentration of radioactive materials in the air, water, or food taken into the body. Since it would be impractical to set different Maximum Permissible Concentration (MPC) values of air, water and food for radiation workers as a function of age, the MPC values are selected in such a manner that they conform to the above-stated limits when applied to the most restrictive case; viz., they are set to be applicable to radiation workers of age 18. Thus, the values are conservative and are applicable to radiation workers of any age (assuming there is no occupational exposure to radiation permitted at age less than 18.)

The maximum permissible average concentrations of radionuclides in air and water are determined from biological data whenever such data are available, or are calculated on the basis of an averaged annual dose of 15 rems for most individual organs of the body, 30 rems when the critical organ is the thyroid or skin, and 5 rems when the gonads or the whole body is the critical organ. For bone-seekers the maximum permissible limit is based on the distribution of the deposit, the Relative Biological Effectiveness (RBE), and a comparison of the energy release in the bone with the energy release delivered by a maximum permissible body burden of 0.1 μg Ra^{226} plus daughters.

2. Emergency Dose (Radiation Workers)

An accidental or emergency dose of 25 rems to the whole body or a major portion thereof, occurring only once in the lifetime of the person, need not be included in the determination of the radiation exposure status of that person.

3. Medical Dose (Radiation Workers)

Radiation exposures resulting from necessary medical and dental procedures need not be included in the determination of the radiation exposure status of the person concerned.

4. Dose to Persons in the Neighborhood of Controlled Areas

The radiation or radioactive material outside a controlled area, attributable to normal operations within the controlled area, shall be such that it is improbable that any individual will receive a dose of more than 0.5 rem in any 1 year from external radiation.

The maximum permissible average body burden of radionuclides in persons outside of the controlled area and attributable to the operations within the controlled area shall not exceed one-tenth of that for radiation workers. This will generally entail control of the average concentrations in air or water at the point of intake, or of the rate of intake to the body in foodstuffs, to levels not exceeding one-tenth of the maximum permissible concentrations allowed in air, water and foodstuffs for continuous occupational exposure. The body burden and concentrations of radionuclides may be averaged over periods up to 1 year.

The maximum permissible dose and maximum permissible concentrations of radionuclides as recommended above are primarily for the purpose of keeping the average dose to the whole population as low as reasonably possible, and not because of the likelihood of specific injury to the individual.

Discussion

A minor difference will be noted between the above recommendation and those of the International Commission on Radiation Protection, (ICRP). The NCRP allows the skin only 6 rems in any 13-week period as compared with 8 rems allowed by the ICRP. The difference is unimportant, and the NCRP would probably have adopted the value of 8 rems had not its recommendations been published nearly a year earlier. The ICRP also uses a value of 8 rems in any 13 weeks as an upper limit for the dose to the thyroid; the NCRP has not specifically stated a 13-week limit for the thyroid. Any calculations in the NCRP report involving the skin or thyroid are based on the ICRP value of 8 rems in any 13 consecutive weeks.

The decision of the ICRP (1956) to set the average external occupational exposure at 5 rems per year (corresponding to 0.1 rem per week) is not applied to internal dose calculations except in the cases of radionuclides that are distributed rather uniformly throughout the body or are concentrated in the gonads. The purpose of limiting the average weekly total body dose (0.1 rem) to 1/3 of the former maximum weekly dose (0.3 rem) was to lessen the possible incidence of certain types of somatic damage; e.g., radiation-induced leukemia and shortening of life span, which are considered to result primarily from total body exposure. Obviously, the reduction in the gonad dose was intended to lower the incidence of deleterious genetic mutations that could give rise to effects appearing in future generations.

Inasmuch as the restriction of integrated dose applies primarily to the total body and gonad dose, there is no basic change in the permissible RBE dose rate when individual organs such as liver, spleen, bone, gastrointestinal (GI) tract, and kidney are the critical body organs for reasons given in ICRP report. It should be noted that the limits recommended here are maximal. In practice, the average occupationally-exposed individual would receive a much lower dose.

Because the direct determination of the body burden or of the dose to an organ or to the total body is generally difficult, and because in most cases measures to decrease the body burden are rather ineffective and difficult to apply, the only practical procedure for general protection of occupational workers is to limit the concentration of the various radionuclides in the water, food, or air available for consumption. It is recommended, therefore, that:

a) If there be no occupational external exposure, the concentration of a radionuclide or a

mixture of radionuclides in air and in water which might be consumed by plant personnel during a 40-hour week be kept at levels not exceeding the appropriate MPC values given here. If there be occupational external exposure, the MPC values must be lowered to bring the total RBE doses within the limits prescribed by the basic rules. Thus, if D rem be the quarterly dose permitted to an organ by the basic rules and if external radiation delivers a dose of E rem per quarter, then the MPC based on this organ must be reduced by the factor (D-E)/D.

b) Alternatively, over a period of 13 weeks, the concentrations of the various radionuclides present in air or in water may be allowed to vary, provided the total intake permitted by exposure at the constant levels indicated in subsection (1) above. (It should be realized that while this method is in accordance with the basic recommendations its use is cumbersome, expensive, and generally unreliable because it requires accurate and continuous monitoring of work areas and the keeping of detailed exposure histories for each individual. Its use is, therefore, only justified in exceptional cases.)

The safest and simplest procedure to use in keeping within the basic limits given above is to maintain the level of contamination of the air, water, or food consumed by plant personnel in the controlled area at or below the indicated MPC values. These values are given for an exposure period of 40 hours per week and 168 hours per week in Table I of the National Bureau of Standards' Handbook 69*. If a person's work assignments be such that he spends only 8 hours each week in the exposure area, the applicable MPC values are 5 times those listed for a 40-hour week in the above cited Table 8. However, this requires considerable care to determine that he be effectively unexposed during the remainder of his working week. If he spends 48 hours each week in the exposure area, the applicable MPC values are five-sixth of those listed for a 40-hour work week.

Although the formula 5 (N-18) permits an average yearly dose to the total body and the gonads of only 5 rems, the rules of the NCRP permit up to 3 rems during any interval (e.g., 1 minute, 1 day, 1 week, etc.) provided that not more than 3 rems are received in any 13 consecutive weeks. Thus an older person may receive up to 12 rems external exposure in a single year provided his dose does not exceed the limits prescribed by the formula 5 (N-18). Although this flexibility is allowed in principle for internal exposures, in practice it is risky and usually impractical to increase the MPC values much beyond those determined for operation over an extended period. The permissible levels do, however, take into account the exposure period, and if the occupational exposures last for only 1 hour per week, the MPC values for a 40-hour week may be increased by a factor of 40. As an example, take the case of a specific situation where sufficient monitoring is available (i.e., external monitoring meters, body fluid analyses, air surveys, etc.) and where no exposure has been received for the prior 13-week period. If the restriction implied by the formula 5 (N-18) is not exceeded, the person may work for 1 hour where the concentration in air of an isotope with the total body as the critical organ is roughly 1200 times the Maximum Permissible Concentration in air $(MPC)_a$ for a 40-hour week.

In such a case no further exposure shall be permitted in the succeeding 13 weeks. This practice should be discouraged because of delays and inaccuracies in methods of estimating the body burden and dose to the organ from such an internally deposited radioactive material. However, if such exposures to contaminated air are unavoidable, the dose may be reduced materially if appropriate and properly fitting respirators are worn.

While these revised MPC and body burden values presented here take into account many refinements previously neglected, there remain many serious uncertainties in the basic biological data on which the calculations are based and thus it is necessary to urge that all exposures be kept to the minimum practically obtainable.

The following is an excerpt of Table 8 of the National Bureau of Standards' Handbook 69, June 1959 referred to above and in the subsequent text. (The sanitarian should consult the NBS Handbook 69 for the complete Table 8):

*Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, June 1959.

Table 8

Maximum permissible body burden and maximum permissible concentrations of radionuclides in air and in water for occupational exposure

1	2	3	4	5	6	7
Radionuclide and Type of Decay	Organ of reference (Critical organ in boldface type)	Maximum permissible burden in total body q (μc)	Maximum permissible Concentrations			
			For 40 hour week		For 168 hour week	
			$(MPC)_w$ μc/cc	$(MCP)_a$ μc/cc	$(MPC)_w$ μc/cc	$(MPC)_a$ μc/cc
$_6C^{14}$ (CO_2) (β^-)	Fat	300	0.02	$4X10^{-6}$	$8X10^{-3}$	10^{-6}
(Sol)	Total Body	400	0.03	$5X10^{-6}$	0.01	$2X10^{-6}$
	Bone	400	0.04	$6X10^{-6}$	0.01	$2X10^{-6}$
(Immersion)	Total Body			$5X10^{-5}$		10^{-5}
$_{38}Sr^{90}$ (β^-) (Sol)	Bone	2	$4X10^{-6}$	$3X10^{-10}$	10^{-6}	10^{-10}
	Total Body	20	10^{-5}	$9X10^{-9}$	$4X10^{-6}$	$3X10^{-10}$
	Gastrointestinal		10^{-3}	$3X10^{-7}$	$5X10^{-4}$	10^{-7}
(Insol)	Lung			$5X10^{-9}$		$2X10^{-9}$
	Gastrointestinal		10^{-3}	$2X10^{-7}$	$4X10^{-4}$	$6X10^{-8}$

Maximum Permissible Values for Occupational Exposure to Radiation

Assumptions and Restrictions Applying to Maximum Permissible Exposure Values Found in Table 8 referred to above.

The values of q (Maximum Permissible Body Burden) and MPC for an individual will depend upon many factors such as his age, physical condition, eating habits, and hygienic standards. They will depend also upon the physical and chemical properties of the radioactive material and the method of intake; i.e., by ingestion, by inhalation, through wounds, or by absorption through the skin. The paucity of data concerning the effect of most of these factors does not warrant detailed treatment. To keep the reasonable limits and yet to meet the major needs of scientific and industrial users of radionuclides, it has been necessary to limit severely the number of factors considered. Therefore, MPC values are listed only for relatively insoluble and for the more common soluble compounds, and these compounds are specified only by the extent of solubility rather than by specific chemical structure. The only methods of intake considered are ingestion and inhalation, except in a few cases where immersion presents the great est hazard criterion. All calculations are based on a "standard man" and thus do not provide for individual variations. The standard man is specified in the ICRP Internal Radiation report and is designed to represent a typical or average adult who is exposed occupationally.

Ideally, maximum permissible body burden, q, and maximum permissible concentration, MPC, should be based on studies of humans who have been exposed to and who have ingested a particular radionuclide under the working conditions and over an extended period of time approximating those which are typical of the average occupational exposure. However, human data are very scarce and only in the case of radium does one have an accumulation of human experience for as long as 50 years, which is the minimum for selecting values for chronic exposure to man. Studies using total and partial body counters have been made recently to determine the uptake, distribution, and elimination of trace quantities of some radionuclides in the human body. In a few cases, certain radionuclides have been taken into the body. The data

from these cases of human exposure have been studied carefully, and, where possible, such data have been substituted here for earlier data based on animal experiments. For the majority of radionuclides, human data are lacking, and in such cases data from animal experiments must be extrapolated to man. Sometimes even animal data are not available and estimates are made from comparison with elements having similar chemical behavior. Because of the many assumptions and approximations made in applying much of the data, it is concluded that detailed refinements in the calculations generally are unwarranted.

In Table 8, as illustrated above, are the recommended values of maximum permissible total body burden, q, and maximum permissible concentration in air, $(MPC)_a$, and in water, $(MPC)_w$, for about 240 radionuclides. The daily intake of water used in calculating $(MPC)_w$ includes the water content of food and thus consideration of the intake of a radionuclide in food is necessary only in case it concentrates in the food during processing or enters the food from other sources. In such cases, the $(MPC)_w$ values of Table 8, converted to microcuries per gram, are applicable when corrected for daily intake, i.e., to take account of the total intake of radionuclides in the complete diet. With few exceptions (e.g., certain daughter radionuclides and isomeric states) radionuclides with radioactive half-lives shorter than 1 hour are not considered in Table 8. The following are the principal assumptions and factors which were used in the calculations of Table 8.

a. In all cases the values are listed both for soluble and for insoluble compounds (an exception is the case of some of the inert gases for which values are given only for the immersion of a person in the inert gas). The lowest values of $(MPC)_a$ and $(MPC)_w$ are given in boldface type both for the soluble and insoluble forms of the isotope. The organs on which these values are based are termed the critical organs and are also boldface in Table 8.

b. In all cases, the values are computed for occupational exposure at the rate of 40 hours per week, 50 weeks per year for a continuous work period of 50 years, as well as for 50 years of continuous exposure, i.e., 168 hours per week.

c. In all cases, the calculated dose rate which determines the MPC takes into account the actual amounts of the radionuclide in the body or critical organ rather than assuming a state of equilibrium. The MPC values based on a critical organ are set by the requirement that the dose rate (rem per week) after 50 years of occupational exposure shall not exceed the above stated values. During a 50-year exposure period, equilibrium is reached for the vast majority of the radionuclides because the effective half-life is short compared to this work period. Exceptions to this rule are listed in Table 9. Column 5 of Table 9 gives the effective half-life, and column 6 gives the percent of equilibrium the body burden attains as a result of constant exposure to the MPC over a period of occupational exposure lasting 50 years. Most of the exceptions are in the rare earth group of elements which are assigned a biological half-life of 200 years. The extreme case is represented by 10 of these radionuclides which reach only 16 percent of equilibrium in the body in 50 years of occupational exposure.

d. In the case of a radionuclide which decays to form radioactive daughters, the calculation assumes that only the parent radionuclide enters the body, but the estimated dose rate includes all the energy released by the daughter elements formed in the body. There are two exceptional cases Rn^{220} and Rn^{222}, where a state of equilibrium typical of that attained in ordinary air is assumed. In all other cases it is assumed that only the parent element enters the body.

e. If occupational exposure continues beyond 50 years, the dose rate will continue to rise in the case of the radionuclides listed in Table 9 because they are not in a state of equilibrium under the assumed conditions of constant exposure level at the MPC, but for the radionuclides not listed in Table 9, the maximum permissible dose rate would not be exceeded. However, since the period of occupational exposure probably will not greatly exceed 50 years, and since the maximum permissible body burden, q, would be reached only after 50 years of occupational exposure at the MPC values given in Table 8, the average RBE dose rate over the working life of the individual will be well below the maximum permissible RBE dose rate even for the isotopes in Table 9.

f. With one exception, chemical toxicity is not considered in estimating the body burden or MPC values. However, in the case or uranium, the chemical toxicity has been considered and is the limiting criterion for the longer-lived nuclides or uranium.

g. In Table 8, the units are the microcurie (μc) and microcurie per cubic centimeter (μc/cc) for maximum permissible quantities of the various radionuclides in the total body, q, and for the maximum permissible concentrations in air, $(MPC)_a$, and in water, $(MPC)_w$.

h. The values of body burden, q, in column 3 of Table 8 are based on that amount of the radionuclide which is deposited in the total body and produces the maximum permissible RBE dose rate to the body organ listed in column 2. The concentration values in water (columns 4 and 6) and in air (columns 5 and 7) are in turn based on the intake by the standard man who accumulates this body burden as a consequence of occupational exposure for a period of 50 years. In most cases, significantly different values of body burden result when effects on different organs are considered. The critical organ is determined by the following criteria: (1) the organ that accumulates the greatest concentration of the radioactive material; (2) the essentialness or indispensability of the organ to the well-being of the entire body; (3) the organ damaged by the entry of the radionuclide into the body; and (4) the radiosensitivity of the organ, e.g., the organ damaged by the lowest dose. In the present state of our knowledge the organ giving the lowest MPC value seems the most likely choice as the critical organ; therefore such organs and such minimal values are printed in boldface type. For each isotope the MPC values are listed first for soluble materials and then for insoluble materials. The values for soluble materials are ranked with increasing magnitude of $(MPC)_w$ so that the first line in this group designates the critical organ determined primarily on the basis of having the lowest $(MPC)_w$. The values for insoluble materials are ranked according to the magnitude of $(MPC)_a$.

i. The total body is listed as an organ of reference for all nuclides except a few of the inert gases. Values for the total body are included primarily as an aid in computing MPC values for mixtures, and as a check on the oversimplified measuring methods used. The MPC based on the retention of radionuclides in the total body also supplies a ready means of estimating the integrated dose, i.e., the dose to the body as a whole. While the basic rules do not directly limit the integrated dose except in the case of whole body irradiation, knowledge of it is of considerable interest. Because the total body limit for constant-level exposure is based on an average of 5 rems per year (0.1 rem per week), the total body is sometimes the critical organ. Because the GI tract often receives a greater absorbed dose than any other body organ, and is frequently the critical organ for exposure to mixed fission products, it is, with few exceptions, included as an organ of reference for the soluble form of the radionuclides. MPC values are given also for the insoluble form of the radionuclides in which case the critical organs are the lungs or the GI tract.

j. The average rate of water consumption used is 1100 ml per 8 hour work day which is actually 1/2 the water consumed in 24 hours.

10^4 liters is used as the average air intake for an 8 hour work day. This is actually 1/2 the air breathed in 24 hours.

The dose from inert gases with radiation of sufficient energy to penetrate the minimal epidermal layer (7mg/cm) results from external exposure to the surrounding cloud of radioactive gas rather than from the amount of gas in the body.

Maximum Permissible Concentration of Unidentified Radionuclides (MPCU)

The identity of the radioactive contaminants in air, water, and food must be established before appropriate MPC values can be applied either for occupational exposure or for exposure to population outside of controlled areas. In many cases, there is no question regarding the identity of a radionuclide because the operation involves only one radionuclide. Sometimes, however, preliminary surveys of radioactive contamination leave considerable uncertainty as to which radionuclides are the major contributors. When a laboratory is using a number of radionuclides, such as mixed fission products, an air sample may furnish only a few clues as to the identity of the radionuclide. By using the simplest of equipment and techniques, the level of air contamination may be established in a matter of minutes, but hours or even days may

be required to conduct the radio-chemical analyses necessary to identify the particular radionuclides that are present in the air. Fortunately, in such cases it is usually not necessary to go through a tedious, time-consuming and expensive radiochemical analysis. If it be known that certain of the more dangerous radionuclides could not be present (i.e., the concentration of the more dangerous radionuclides is small compared with the MPC values in Table 8) the operation may be continued safely regardless of the radionuclide or mixture of radionuclides provided the concentration does not exceed the values for MPC of unidentified radionuclides (MPCU) as listed in Table 10 for water or in Table 11 for air. These MPCU values are applicable to continuous occupational exposure (168 hours per week) and should be multiplied by 1/10 if they are to be applied as interim values outside, and in the neighborhood of, the controlled exposure areas. It should be pointed out that the use of MPCU values may save an immense amount of effort and expense if they be applied properly to avoid unnecessary radionuclide analyses in areas where the air, water, and food contamination is usually less than the appropriate MPCU values. On the other hand, they can impose a needless penalty if improperly applied. For example, if initial measurements indicate a negligible amount of Ra^{226} and Ra^{228} in the drinking water of a small community near an atomic energy laboratory, and if it be determined by daily gross β and γ sample counting that the activity does not exceed the $(MPCU)_W$ value, ($1/10 \times 1 \times 10^{-6}$ μc/cc = 1×10^{-7} μc/cc) it would seem foolish to carry out a radiochemical analysis of this water. If, on the other hand, the level ranged between 10^{-5} and 2×10^{-5} μc/cc, it would be unwise to shut down the plant or to instigate an expensive modification of the operation without first identifying the radionuclides for it might be that the contamination of the water is from Na^{24} and P^{32}. In this case, the appropriate $(MPC)_W$ value for application in the neighborhood of the plant is $1/10 \times 2 \times 10^{-3} = 2 \times 10^{-4}$ and $1/10 \times 2 \times 10^{-4} = 2 \times 10^{-5}$, respectively (calculated from Table 8).

Table 9.--Radionuclides which do not reach equilibrium in the body within 50 years

Z	Radionuclide	Radioactive half-life T_r (yr)	Biological half-life T_b (yr)	Effective half-life T (yr)	Percent equil. reached in 50 yr
38	Sr^{90}	28	50	18	86
88	Ra^{226}	1622	45	44	56
89	Ac^{227}	21.8	200	20	83
90	Th^{230}	8.0×10^4	200	200	16
90	Th^{232}	1.39×10^{10}	200	200	16
91	Pa^{231}	3.4×10^4	200	200	16
93	Np^{237}	2.20×10^6	200	200	16
94	Pu^{238}	89.6	200	62	43
94	Pu^{239}	2.44×10^4	200	200	16
94	Pu^{240}	6.6×10^3	200	190	16
94	Pu^{241}	13.2	200	12	94
94	Pu^{242}	3.8×10^5	200	200	16
95	Am^{241}	462	200	140	22
95	Am^{243}	8×10^3	200	200	16
96	Cm^{243}	35	200	30	69
96	Cm^{244}	18.4	200	17	87
96	Cm^{245}	2×10^4	200	200	16
96	Cm^{246}	6.6×10^3	200	190	16
98	Cf^{249}	4.7×10^2	200	140	22
98	Cf^{250}	10	200	10	97

Table 10.--Provisional maximum permissible concentration of unidentified radionuclides in water $(MPCU)_W$

Values that are applicable for occupational exposure (168 hr/wk) to any radionuclide or mixture of radionuclides	
Limitations	μc/cc of water**
If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226} Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present* the continuous exposure level $(MPC)_w$, is not less than	3×10^{-5}
If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, Ra^{223}, Ra^{226}, Ra^{228}, Pa^{231}, and Th-nat are not present* the continuous exposure level $(MPC)_w$, is not less than	2×10^{-5}
If Sr^{90}, Pb^{210}, Ra^{226}, and Ra^{228} are not present* the continuous exposure level $(MPC)_w$, is not less than	6×10^{-6}
If Ra^{226} and Ra^{228} are not present* the continuous exposure level $(MPC)_w$, is not less than	10^{-6}
In all cases the continuous occupational level $(MPC)_w$, is not less than	10^{-7}

*In this case "not present" implies the concentration of the radionuclide in water is small compared with the MPC value in table 1.
**Use 1/10 of these values for interim application in the neighborhood of an atomic energy plant.

Recommendations of Federal Radiation Council

To provide a Federal Policy on human radiation exposure, the Federal Radiation Council was formed in 1959 (Public Law 86-373) to "...advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with States ..."

Among the items considered of most immediate interest by the Federal Radiation Council to the establishment of radiation protection standards excluding major nuclear accidents are the following:

1. Acute doses of radiation may produce immediate or delayed effects, or both.

2. As acute whole body doses increase above approximately 25 rems, immediately observable effects increase in severity with dose, from barely detectable changes to biological signs clearly indicating damage, to death at levels of a few hundred rems.

3. Delayed effects produced either by acute irradiation or by chronic irradiation are similar in kind, but the ability of the body to repair radiation damage is usually more effective in the case of chronic than acute irradiation.

4. The delayed effects from radiation are in general indistinguishable from familiar pathological conditions usually present in the population.

5. Delayed effects include genetic effects, increased incidence of tumors, life span shortening, and growth and development changes.

6. The child, the infant, and the unborn fetus appear to be more sensitive to radiation than the adult.

7. The various organs of the body differ in their sensitivity to radiation.

8. Although ionizing radiation can induce genetic and somatic effects (effects on the individual during his lifetime other than genetic effects), the evidence at the present time is insufficient to justify precise conclusions on the nature of the dose-effect relationship especially at low doses and dose rates. Moreover, the evidence is insufficient to prove either the hypothesis of a "damage threshold" (a point below which no damage occurs) or the hypothesis of "no threshold" in man at low doses.

It should be noted that the radiation exposure to patients by practitioners of the healing arts is in the same order as natural background, when averaged over the population. The average exposure to the U.S. population from activities of the nuclear energy industry, under current practices, is less than that from background by a substantial factor.

The presence of a threshold for radiation damage could not be established by adequate scientific evidence. With the accumulation of quantitative information concerning radiation effects in both animals and humans, and some increased understanding of the mechanisms of radiation injury, the possibility that somatic effects as well as genetic effects might have no threshold appears acceptable, as a conservative assumption, to increasing numbers of scientists. On the basis of this conservative assumption, radiation protection standards must be established by a process of balancing biological risk and the benefits derived from radiation use.

Under the working assumptions used, there can be no single "permissible" or "acceptable" level or exposure, without regard to the reasons for permitting the exposure. The radiation dose to the population which is appropriate to the benefits derived will vary widely depending upon the importance of the reason for exposing the population to a radiation dose. Also, under the assumptions used, all exposures should be kept as far below any arbitrarily selected levels as practicable. There should not be any man-made radiation exposure without the expectation of benefit resulting from such exposure. Any numerical recommendations should be considered

as guides, and the need is for a series of levels, each of which might be appropriate to a particular action under certain circumstances.

Table 11. --Annual Natural Background Dose, Estimated by Laughlin and Pullman

Radiation Source	Gonadal		Bone Marrow	
	Millirad	Millirem	Millirad	Millirem
Cosmic rays	26 ± 3	26 ± 3	26 ± 3	26 ± 3
Earth, housing	53 ± 20	53 ± 20	59 ± 20	59 ± 20
Atmospheric	2 ± 1	2 ± 1	–	–
Internal radioactivity:				
Beta and gamma rays	18 ± 3	18 ± 3	5 ± 1	5 ± 1
Alpha particles	0.5 ± 0.3	5 ± 3	4.5 ± 2	45 ± 20
Total		104 ± 21		135 ± 30

American Public Health Assn., Public Exposure to Ionizing Radiation, 1958

Radiation Protection Guide

The term "maximum permissible dose" is used by the NCRP and ICRP for the radiation worker. However, this term is often misunderstood. The words "maximum" and "permissible" both have unfortunate connotations not intended by either the National Committee on Radiation Protection or the International Committee on Radiation Protection. Therefore the term Radiation Protection Guide (RPG) has been introduced. This term is defined as, the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable.

There can, of course, be quite different numerical values for the Radiation Protection Guide, depending upon the circumstances. It seems useful, however, to recommend Guides which appear appropriate for normal peacetime operations. The following Radiation Protection Guides are recommended for normal peacetime operations:

Type of exposure	Condition	Dose* (rem)
Radiation worker:		
(a) Whole body, head and trunk, active blood forming organs, gonads, or lens of eye.	Accumulated dose	5 times number of years beyond age 18
	13 weeks	3
(b) Skin of whole body and thyroid	Year	30
	13 weeks	10
(c) Hands and forearms, feet and ankles.	Year	75
	13 weeks	25
(d) Bone	Body burden	0.1 Microgram of radium-226 or its biological equivalent
(e) Other organs	Year	15
	13 weeks	5
Population**		
(a) Individual (whole body)	Year	0.5
(b) Average (gonads)	30 years	5

* Minor variations here from certain other recommendations are not considered significant in light of present uncertainties.

** These values differ from those applicable to radiation workers.

These guides are not intended to apply to radiation exposure resulting from natural background or the purposeful exposure of patients by practitioners of the healing arts.

The term Radioactivity Concentration Guide (RCG) is defined as: the concentration of radioactivity in the environment which is determined to result in organ doses equal to the Radiation Protection Guide. Within this definition, Radioactivity Concentration Guide can be established only after the Radiation Protection Guide is decided upon. Any given Radioactivity Concentration Guide is applicable only for the circumstances under which use of its corresponding Radiation Protection Guide is appropriate.

Reasonably accurate estimates can be made of the amount of internally deposited radioactive material resulting in any particular organ dose. However, the establishment of guides as to the amount of material which, when taken into the body, will yield such organ doses is fraught with many uncertainties.

Where appropriate radioactivity concentration guides are not available, and where Radiation Protection Guides for specific organs are provided, the latter Guides can be used for the derivation of radioactivity concentration guides applicable to their particular problems. There is no simple numerical relationship between Radioactivity Concentration Guides for the worker and for the general population.

Under certain conditions, such as widespread radioactive contamination of the environment, the only data available may be related to average contamination or exposure levels. Under these circumstances, it is necessary to make assumptions concerning the relationship between average and maximum doses. The Federal Radiation Council suggests the use of the arbitrary assumption that the majority of individuals do not vary from the average by a factor greater than three. Thus, the use of 0.17 rem is recommended for yearly whole-body exposure of average population groups. (It is noted that this guide is also in essential agreement with current recommendations of the NCRP and the ICRP.) It is critical that this guide be applied with reason and judgment. Especially, it is noted that the use of the average figure, as a substitute for evidence concerning the dose to individuals, is permissible only when there is a probability of appreciable homogeneity concerning the distribution of the dose within the population included in the average. Particular care should be taken to assure that a disproportionate fraction of the average dose is not received by the most sensitive population elements. Specifically, it would be inappropriate to average the dose between children and adults, especially if it be believed that there are selective factors making the dose to children generally higher than that for adults.

When the size of the population group under consideration is sufficiently large, consideration must be given to the contribution to the genetically significant population dose. The Federal Radiation Council endorses in principle the recommendations of such groups as the NAS-NRC, the NCRP, and the ICRP concerning population genetic dose, and recommends the use of the Radiation Protection Guide of 5 rem in 30 years (exclusive of natural background and the purposeful exposure of patients by practitioners of the healing arts) for limiting the average genetically significant exposure of the total U. S. population. The use of 0.17 rem per capita per years as a technique for assuring that the basic Guide for individual whole body dose be not exceeded, is likely in the immediate future to assure that the gonadal exposure Guide is not exceeded.

Radiation Protection Guides for Occupational Exposure*

Extrapolation from experience with background radiation to the exposure of the relatively small percentage of the population in the radiation industry is rather unsatisfactory. It is possible to estimate the maximum biological damage which could be reasonably expected to result

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* In the formulation of Radiation Protection Guides for occupational exposure, special consideration has not been given in this staff report to the possible existence of pregnancy among female workers.

from a given radiation exposure. Using such estimates, a numerical value can be selected at which the radiation risk appears so small as to be justified by even a relatively minor benefit. The NCRP recommends that, for occupational exposure, the radiation dose to the whole body, head and trunk, active blood forming organs, or gonads, accumulated at any age, shall not exceed 5 rems multiplied by the number of years beyond age 18, and that the dose in any 13 consecutive weeks shall not exceed 3 rems. The Federal Radiation Council agrees with the opinion of the NCRP that this dose of ionizing radiation is not expected to cause appreciable body injury to a person at any time during his lifetime. Thus, while the possibility of injury may exist at this dose, the probability of detectable injury is almost certain to be extremely low. Even the use of the more pessimistic assumptions would indicate that the small risk involved is acceptable if the gain be of any significance. Fortunately, this level also appears to be one which is not unduly restrictive in ordinary working circumstances.

Relative Biological Effectiveness

The same absorbed dose of different kinds of radiation does not, in general, produce the same biological effect. Different kinds of radiation have a different relative biological effectiveness (RBE). It is well known that the RBE for a particular kind of radiation may be dependent upon such factors as the specific biological effect under consideration, the tissue irradiated, the radiation dose, and the rate at which it is delivered. Recommendations on radiation protection have generally assumed a specific RBE for each kind of radiation.* The RBE dose is equal numerically to the product of the dose in rads and an agreed conventional value of the relative biological effectiveness. The unit of RBE dose is the rem, considered to be that dose which is biologically equivalent to one roentgen of x- or gamma-radiation. For example, one rad of neutrons is conventionally considered to be equivalent to 10 roentgens of gamma radiation, and this equivalence is expressed by saying that the RBE dose is 10 rem. However, it has been found experimentally that the same RBE dose of different radiation sources in the bone does not always produce the same biological effect. A numerical factor called the relative damage factor is introduced to take care of this difference. Thus, in the case of bone, the biological effect is represented by the product of the RBE dose and the relative damage factor.

Radiation Protection Standards for Population in Peacetime

The Federal Radiation Council has established the following safety standards for daily levels of intake of radioactivity from fallout for the general population in peacetime.

RANGE I. Includes intakes which would not be expected to result in any appreciable number of individuals reaching a large fraction of the radiation dose prescribed in the Radiation Protection Guides. The only action required is periodic surveillance accurate enough to provide reasonable confirmation of calculations.

RANGE II. Includes intakes which would be expected to result in average exposure not exceeding the radiation dose prescribed by the Radiation Protection Guides.

Therefore, such intakes call for active quantitative surveillance and routine control.

RANGE III. These intakes would be presumed to result in exposures exceeding the Radiation Protection Guides dose, if continued for a sufficient period of time. Therefore, any intake within this range must be evaluated from the point of view of instituting appropriate positive control measures if necessary.

Table 12. RADIOACTIVITY INTAKE

	For Average Population During Normal Peacetime (micromicrocuries per day)			
	Radium-226	Iodine-131	Strontium-90	Strontium-89
Range I	0-2	0-10	0-20	0-200
RANGE II	2-20	10-100	20-200	200-2000
RANGE III	20-200	100-1000	200-2000	2000-20,000

* Currently used values of RBE (relative to x-rays) are 1 for x-rays, gamma rays, and electrons; 10 for neutrons and protons up to 10 Mev, and alpha particles; and 20 for heavy recoil nuclei. These are for chronic irradiation and should be used only for protection purposes.

The recommended tolerance level of total intake for iodine-131 is 10 to 100 micromicrocuries per day for the duration of a year for small children. The Medical Research Council of Great Britain states that the acceptable tolerance dose for iodine-131 would not be exceeded in any age group of the population unless an average concentration in the milk reached 130 micromicrocuries per liter for the period of a year, or higher concentration for correspondingly shorter periods.

(A micromicrocurie is one millionths of one millionth of a curie, 1 curie being equal to the amount of radioactive material that disintegrates at the rate of 37 billion disintegrations per second which is equivalent to the radioactivity per second of 1 gram of radium.)

Hazards in Handling Radioisotopes

Prior to the war, the use of radioisotopes was essentially limited to a few locations having access to cyclotron-induced activities. The addition of pile-induced activities either as fission products or as special irradiations has changed the magnitude of the related protection problems. Widespread location of production plants, and laboratory and industrial use of radioisotopes are foreseen. At the close of 1948, fissionable-material production extended into at least 15 states of the nation, and was carried on in 30 separate plants at 25 locations. By 1965, this had been extended to many more states and places. The use of fissionable material in various laboratories for medical, chemical, agricultural and other research purposes already extends over the entire country. This involves the protection of scientists and technicians, of industrial employees, and of the public. In all cases, management specifically assumes the responsibility for the proper selection and maintenance of the standards necessary for safe operation while government must assume the responsibility for setting standards and regulations for the protection of the public's health and insuring the execution of such measures. The small laboratory, handling low levels of radioactivity, may modify or omit some of the safety recommendations required for larger units. A periodic review of such modifications by a competent radiation protection authority is desirable. The large laboratories and industries will require more detailed control. The employment of full-time personnel qualified in radiation protection is desirable, and should be mandatory where the staff handling radioactive material exceeds 25.

Radiation hazards are determined by:

1) The amount of radiation received in a particular interval of time in a smaller or larger area of the body.

2) Whether the radiation be external, as, for example, such that comes from the X-ray tube, from a source of radium, or from an atomic pile. Whether it affects the body as a whole due to lack of shielding or focusing, or whether it affects only certain parts of the body due to the nature of the shielding, such as the shape of the opening in the shield, or the amount of protection surrounding the source of radiation.

3) Whether the radiation be internal, i.e., taken into the body by ingestion, inhalation, or through breaks in the skin, and in what degree the following factors obtain:

a) The quantity absorbed into the tissues. Among the very dangerous materials is plutonium. If it be swallowed, very little is absorbed because it is insoluble in the intestinal tract.

b) The quality of the radiation, i.e., whether the material absorbed emits alpha, beta, gamma radiations, or in rare instances, neutrons.

c) The place in the body where the material settles. Radioactive sodium-24 and chlorine-36 will diffuse themselves throughout the body. Iodine, on the other hand, will concentrate in the thyroid gland and strontium in the bones. Carbon-14, phosphorus-32, calcium-45, arsenic-76, strontium-89 and -90, and barium-131 are deposited in the bones; sulphur-35, copper-64, gold-198 and -199, mercury-197 and bismuth-210 are deposited in the liver; potassium-42 and iron-55 and -59 are deposited in the blood; arsenic-77 is deposited in the hair, and potassium-42 will also be deposited in the muscles. Other isotopes will concentrate in other parts of the body.

d) The rate of excretion from the body. Sodium leaves through the urine almost as fast as it enters the body. Strontium and plutonium, on the other hand, are deposited in bones and may remain there for extended periods. Carbon-14, phosphorus-32, sulphur-35, chlorine-36, potassium-42, calcium-45, cobalt-60, copper-64, arsenic-76 and -77, strontium-89 and -90, iodine-130 and -131, and gold-198 and -199 are eliminated through the urine; carbon-14, calcium-45, strontium-89 and -90 are also eliminated in feces and so are manganese-52 and -54, iron-55 and -59, and barium-131 and -140; carbon-14 is also eliminated through the lungs.

e) The half-life of the material. Fluorine, with 118 minutes of half-life cannot be a serious radiation hazard in ordinary quantities. Carbon, on the other hand, with half-life of 5,100 years is a dangerous hazard.

To produce damage in the body, radiations must reach the vital tissues. Since alpha particles are highly ionizing, they are about 10,000 times as effective as gamma rays, but the range of action is limited by their poor penetration which is about 0.1 mm. in tissue. This eliminates alpha particles as an external hazard since they may be shielded out with a piece of paper or the skin itself. But when they are deposited internally in the bond marrow, severe damage may result because of their high ionizing ability.

Beta particles, like alpha particles, produce ionization but have poor penetrating ability which is about 5 to 10 mm. in tissue. They are dangerous when taken into the body, and since they have a strong caustic effect on the skin at short distances, they must also be considered among the external hazards.

Gamma rays have a much less degree of ionization per centimeter of the distance they travel than alpha or beta particles, but their ability to penetrate and reach the deep tissues and cause "pair production" in the cells makes them a particular hazard in external radiation.

Neutrons are also penetrating (depending on their energies), and their power of ionization is about 5 to 6 times as effective as that of the gamma rays, which places these particles among the serious external hazards.

Severe radiation hazard is associated with those isotopes that have unfavorable combinations of long half-life, high uptake, deposition in small organs or in bone, and low elimination rates.

Ingestion may occur as an acute problem through the accidental drinking of an active solution. More generally, it will be a chronic problem caused by accumulation of small amounts of activity on contaminated hands, cigarettes and other items brought to the mouth, or as secondary result of inhalation. Following ingestion, the hazard may be due to direct irradiation of the alimentary tract, or more probably due to chronic irradiation of the organs in which the particular active materials are concentrated. Inhalation of active gas, vapor, spray, or dust, may occur. Exposure to spray or dust is considered particularly hazardous because of the large fraction of such contamination retained by the lungs. Following inhalation, the hazard is threefold:

a) Direct irradiation of the lungs, etc.
b) Absorption of the active material directly from the lung.
c) Elimination from the lung by ciliary action followed by ingestion.

Chronic deposition of unabsorbable particles in the lungs is a major hazard since is is extremely difficult to demonstrate the accumulation of such particles. Once radioactive material has entered the body and been deposited in the organs governed by its metabolism, it is difficult or impossible to expedite the natural rate of elimination from the organ. It is, therefore, essential to avoid all ingestion or inhalation of radioactive materials and to test potentially exposed personnel for such accumulations whenever a suitable method exists.

Absorption of active materials through an open cut or even through the intact skin is a potential hazard when more than tracer doses are handled. Retention of activity in the skin itself is known to be able to produce tumors.

The fundamentals of decontamination against radioactivity are:

1. The personnel doing the work must be protected by all means possible.
2. The rate of radioactive decay cannot be changed, therefore the only courses of action are:
   a. Wait for the radioactive material to decay to within safe limits; or
   b. Move it to another place where it is less of a hazard or less inconvenient; or
   c. Shield it so the intensity of radiation is reduced to within safe limits outside the shield; or
   d. Some combination of two or all of these procedures.
3. An element or compound even though it be radioactive, retains all of its chemical and physical properties. Therefore those radioactive substances which cannot be decontaminated in their existing forms may be changed by dissolving and washing away or otherwise removed.

It will be necessary at times to undertake decontamination to restore to use premises or materials that are urgently needed. Let us review some of the factors that must be taken into consideration in deciding whether or not decontamination will be attempted. These are:

1. What is the kind and intensity of the radioactive contamination;
2. What is the area or object contaminated;
3. What are the hazards to personnel in the decontamination process.

By the kind and intensity of contamination is meant whether it be alpha, beta, gamma or a combination of these radiations, whether the contamination be heavy as measured in roentgens, millicuries, or other suitable unit, and what is its half life.

If the radioactive contaminant be a long half life alpha, it will not be possible to wait for it to decrease. However, because of the short range of alpha particles, shielding would be effective. On the other hand, if the contaminant be a short half-life gamma emitter, shielding would be more difficult but the rapid decay rate might make it feasible to wait for the intensity of the radiation to drop to within safe limits.

We have already learned that in the event of an atomic explosion, there will be intermingled hundreds of isotopes of dozens of elements from the fission products, unfissioned materials, and possibly neutron induced radioactivity. Therefore, the above examples are oversimplifications and are used only for explanatory purposes.

Concerning the area or object contaminated, we must consider how important is it. If it be possible to get along without it permanently or, if temporarily, for how long? Can it be replaced? What is the cost of decontamination compared to the value of the object? What does it interfere with in its present location and radioactive condition? Is it movable and can it be shielded? Will the object be in a usable state of repair after decontamination, and what are the prospects for a successful decontamination job?

In determining whether or not the undertaking of decontamination be a hazard to personnel who will be called upon to do the work, it is necessary to consider all the principles of personnel monitoring. After evaluating all available personnel protection devices, one must decide whether the benefits to be derived from the decontamination outweigh the hazards of exposure to personnel during the clean-up process.

A great amount of experimental work has been done to develop the most suitable decontamination agents and methods. Much useful information has been acquired but the easy method is still to be discovered. Some of the more effective agents and procedures are the following:

1. Scrubbing with water is about 30% to 50% effective in removing the fission products of an atomic explosion.
2. Citric acid and some other organic acids have the property of forming complex soluble compounds with certain of the fission products. This is particularly pronounced with the rare earths and yttrium. These elements make up 30% or more of the fission products remaining up to at least one year after an atomic explosion. Therefore, contamination can be reduced by about 30% by scrubbing with citric acid solution. It has the added advantage of being comparatively non-injurious to most surfaces.
3. Inorganic acids have good solvent action on many contaminants but will corrode metal surfaces. Corrosive action can be controlled to some extent by choice of temperature, concentration and duration of contact. One of the best acid mixtures for decontaminating metallic surfaces consists of 5 parts of 1 molar hydrochloric acid to 1 part of 0.3 molar citric acid solution. This will corrode metal on long contact but a short bath for a few minutes will not noticeable harm metal. A mixture of phosphoric acid, chromic acid and a wetting agent should be used on metal surfaces particularly susceptible to corrosion by hydrochloric acid.
4. Strong alkali solutions are useful in cleaning up painted surfaces by removing the paint layer, and with it, the contaminant. For application on vertical or sloping surfaces, they should be made into a paste with cornstarch so they will adhere. The heat generated by dissolving an alkali-like caustic soda in water will help in removing the paint film. Such caustic solutions are not injurious to wood.
5. Detergents and soaps are effective on surfaces with greasy films. Radioactive dusts may readily become embedded in and held by these greasy films. Concentrated detergent solution injected into a live steam spray is a most effective decontaminating agent.

6. Organic solvents such as carbon tetrachloride and hydrocarbons are also useful on oily or greasy surfaces. They have the disadvantages of being expensive, not readily available in large quantities, not easily stored, and many are inflammable or toxic.

7. Abrasives of all kinds may be used. A wet sand blast is good on stone, brick, cement and iron but would be injurious to softer surfaces, even to stucco. Also, it presents a problem of disposal of large volumes of contaminated sand. Sawdust is adaptable to use on instruments, apparatus and surfaces that would be damaged by harsher abrasives. Almost any kind of polishing, scouring or buffing tool from floor sanders to tooth brushes may be adapted to some phase of decontamination. Special precautions to protect personnel must be taken when abrasives are used. The dusts and powders formed by a dry abrasive are difficult to confine unless closed systems be employed. There is also danger from inhalation or ingestion. Masks and goggles must be worn by workers. Dusts also tend to shift into the folds of clothing complicating personnel decontamination. Vacuum systems can be used in picking up dry residues but they must have tight receptacles to hold fine dust.

8. Protective strip type coatings are of value where surface contamination can be anticipated as in a laboratory. These are plastics or paints which may be stripped off, removing surface contamination with it. There is also work being done on strip resins to be applied by spraying over contaminated surfaces. When they are stripped off, the contaminant adheres and is thus removed at least in part. Ordinary adhesive tape may be used with some success in this way. After a surface has been cleaned to reasonable limits of contamination, a coat of paint or other dense protective coating would serve to shield against short range alpha and beta contamination.

9. Some surfaces might be decontaminated by planing or sanding or cutting off the outer layers as deeply as the contamination penetrates. Before this is done, attention should be given to the effect of changing the dimensions of the surface so treated. If the reduction in size so affects the object that it would not properly perform its function, such a procedure would be unwise.

10. There is no practical method for decontaminating areas such as fields, parks and lawns. About all that can be done is to cover them with a foot of earth or plow under to a depth of a foot and let time do the rest. If essential streets or walks be unsafe after cleaning and flushing, a layer of blacktop as a shield may solve the problem.

11. Waste disposal must be provided in every decontamination operation. It is a serious problem. If soil, sewers, drains and waterways be already contaminated, liquid flushings and drainings may be permitted to flow onto the ground or into the usual drainage channels.

Selection and Instruction of Personnel. Persons who are naturally neat and careful are preferred workers with radioisotopes. A rigid physical examination should be made of all prospective workers. Careful inspection of the hands, and evaluation of possible previous exposures to radiation, are recommended. All individuals employed in radiation work must be informed in detail of all known dangers involved. They must be instructed regarding local rules and regulations for protection, and should be expected to observe them in all details. It is particularly important that all users of radioisotopes should be considered as potential full-time users.

Physical Examinations. A thorough medical examination should be made of each individual potentially exposed to significant amounts of radiation before employment, and annually thereafter. An examination for possible radioactivity, by a person with special knowledge and equipment, should be given each individual whenever the exposure potential includes significant internal deposition. More frequent examinations are warranted when the exposure potential is high. The nature of such tests will depend upon the particular isotopes to which the individual may have been exposed. Sufficiently sensitive tests for the deposition of all relevant isotopes may not exist.

A complete blood count must be made by a skilled hematologist before any individual begins work involving the handling of radioactive materials. No one should be employed who shows pertinent abnormalities in the blood count. Blood counts should be made at regular intervals during employment with more attention given to the trend of successive counts, and especially of the differential count ratios, than to absolute values. It should not be considered that overexposure of the individual will be detected by changes in blood count.[20] Poor protection techniques may be detected by blood count findings before permanent injury to the individual occurs.

An analysis of radioactivity of the urine is a desired procedure. Normal urine contains radiopotassium in amounts which may mask the added radioisotopes for which tests are made. The potassium should be separated from the sample. Examination of the feces may be required when the predominant elimination is by feces. Special tests for specific isotopes are in order when

20. A single exposure of 25 r can apparently escape detection by standard blood counting techniques.

they exist, (e.g., radio-iodine may be estimated in the thyroid gland in terms of the emitted gamma radiation measured by a Geiger counter or ionization chamber.) Where exposure to radioisotope dust or spray is a possibility, it may be desirable to test the activity of a nasal smear, or of the sputum.

Personal Cleanliness and Care. Radioactive isotopes must be treated like other poisonous substances. Extreme personal cleanliness in the laboratory is therefore desired. The material must not be spilled or scattered, and must not come in contact with the hands or clothing to any appreciable extent. At the end of each work period, the hands and gloves must be carefully washed, and qualitative tests for contamination of hands, clothing and other parts must be made. In those cases where risk of absorption of isotopes through open cuts is important, hands should be inspected at beginning of workday, and those with injuries should be excluded from the work. No edibles of any kind, including chewing gum, candy, or beverages must be brought into the laboratories, nor must they be touched before removing all washable traces of radioisotopes from the hands. The use of cigarettes or application of cosmetics in the laboratory may result in the transference of activity to the lips, therefore smoking or cosmetic application must be permitted only in certain uncontaminated areas.

The hands and shoes should be tested frequently with a Geiger counter or other suitable instrument to determine whether contamination exists.

Adjacent to each counter which is reserved for hand and shoe counting there should be a record sheet on which the individual is to record all counts taken, including high counts and those after washing.

Monitoring of personnel with respect to incident radiation is achieved by use of pocket ion chambers and/or film badges worn on the person. It is standard practice to process the pocket chambers daily, and the film weekly. Where experience has shown continued low exposure, films read every two weeks give an adequate exposure index. Similarly, self-reading pocket chambers may be worn for an extended period if the casual leakage be insignificant. Finger film should be processed at least weekly. In general, each individual using radioisotopes should be responsible for monitoring himself against contamination.

Report to supervisor should be made of any hand or shoe count which is above the specified limiting value marked on the counting machine. If the individual, with the aid of his supervisor, be unable to reduce the count below the limiting value listed on the counting machine, the health supervisory staff should be notified as soon as practical, and in all instances before the individual leaves the plant at the end of the shift.

No work with plutonium[21] in any chemical or physical form should ever be done by a person having a break in his skin below the wrist or with a bandage on his hand. Any person receiving a puncture wound suspected of hazardous radioisotope contamination should report to the doctor at the dispensary immediately.

The pipetting of active solutions by mouth should be forbidden. Glass blowing in laboratories containing active materials should be discouraged. Any person who knowingly swallows, inhales or receives an injection of a radioactive material or who may have been overexposed to radiation from any source should report to the Medical Department at once.

Protective Clothing and Devices

The degree of protection required is a function of the process used. Even trace amounts should be handled with laboratory coats protecting normal attire. Where routing radiochemical or biological work is done, coveralls restricted to this operation should be worn. Protective clothing must not be worn in cafeteria. Rubber gloves should be worn while handling active materials which may give rise to contamination of the hands. Surgical gloves will not stop penetrating beta particles, hence remote handling with tongs and sufficient glassware shielding is necessary in working with strong sources of energetic beta emitters. Surgical gloves can, however, eliminate deposition of active material on the hands. Surgical technique must be used when putting on and removing surgical gloves, in order to avoid the possibility of contaminating the inside surfaces.

21. This rule applies to other radioisotopes which present a similar health hazard (1 microgram Pu or approximately 1/16 microcurie.)

Rubber gloves should be washed and cleaned, if practical, before removal. All rubber gloves should be stored and handled so as to prevent contamination of the inside surfaces. Care should be exercised when using organic solvents to avoid skin contact with radioactive material. (Solvents may make the skin more permeable.) In case radioactive slime accumulates in the plumbing, it can safely be removed by protecting the hands with rubber gloves. If the material be spilled on the floor, special cloth or rubber overshoes should be used. In some cases, the provision of shoes to be used only in the laboratory is preferable.

Good protective practice is similar to, but usually less stringent, than that employed in the manipulation of virulent bacteriological organisms.

Recommended Handwashing and Glove Technique

Surgical technique for putting on and removing rubber gloves. Surgical rubber gloves, used during procedures where hand contamination is probable, should be prepared in advance by powdering the insides and by folding out the wrist portion of the gloves to form a cuff of about two inches:

To put on the gloves the following procedure is advised:

1. The hands are powdered well with talc.
2. The first glove to be donned is grasped at the folded cuff, without touching the exterior of the glove, and pulled onto the fingers and hand, leaving the cuff in the folded position.
3. The second glove is lifted by inserting the fingers of the gloved hand beneath the cuff, and pulling it onto the bare fingers and hand.
4. The cuffs of both gloves are turned back over the wrists, without touching the bare skin
5. The loose fitting glove fingers are then "worked" into position in the same manner as are cloth gloves.

Removal of the gloves is accomplished in the reverse order, in that the fingers of one gloved hand grasp the beaded rim of the top of the glove of the other hand without touching the inside of the glove, and by traction, invert the glove and pull it off the hand. The index finger of the bared hand is now inserted beneath the beaded rim of the top of the other glove and without contacting the exterior surface of the glove, it is inverted and pulled off the hand.

Recommended Procedure for Washing and Decontamination of Hands.

1. Wash thoroughly for two to three minutes by the clock with a teaspoonful of Lan-O-Kleen Soap or equally satisfactory soap using a sufficient amount of tepid (not hot) water to maintain a thin paste, and rub the paste over the entire surface of the hands and fingers. Rinse off completely with water and repeat the process at least three times.
2. If the above procedure be not enough to remove all dirt and contamination, the hands should then be scrubbed for a period of at least eight minutes by the clock with a liquid or cake soap, hand brush, and tepid water, being sure to brush the entire surface of the hands, especially around the nails and between the fingers. Light pressure should be exerted on the brush —do not press so hard that the bristles are bent out of shape. Eight minutes is usually a sufficient time to allow three complete changes of tepid water and soap. Each one of these three washings should be so thorough that the brush will cover all areas a minimum of four strokes. A convenient routine is to start by scrubbing one thumb, being sure to brush all surfaces, proceed to the space between the thumb and first (index) finger and similarly to each finger and the webbs between the fingers. Attention should be given to the palm and back of the hand and finally additional scrubbing of the nails and cuticles before proceeding in an exact manner with the other hand.
3. Lanolin or hand creams may be used after washing to soften the hands and prevent chapping (keeps cracks from forming through which active material might be absorbed.)
4. Additional Method of Decontamination for Fission Products Generally: Titanium dioxide paste (TiO_2) —The material should be made up as a paste or slurry and kept wet with plain or distilled water. It should be applied to the hands as paste and then thinned with tap water while washing. A minimum of 2 minutes of thorough application of this lather to all hand surfaces, especially about the finger nails, is recommended. It should then be thoroughly rinsed off with luke-warm tap water, and followed by a thorough washing with soap and water and a hand brush. If any of the paste be left under the nails after washing, it will form a rather hard cake which is difficult to get off later.

Respirators, Combat Masks or Air Line Hoods

An approved respirator, combat mask, or air line hood should be worn in any location where the concentration of air borne beta and gamma emitters may be greater than 10^{-8} microcuries per cc. It should be the responsibility of the supervisor of the area using respirators to see that these are not used more than once before being sent to the contaminated article laundry for monitoring and cleaning (if necessary.) Combat masks and air line hoods (complete sets) should be monitored and inspected after each use and at two month intervals when not in use.

Housekeeping. Neatness in the laboratory is a prime requisite for elimination of the spread of contamination. The work area should be free from equipment and materials not required for the experiment at hand, and equipment used should be decontaminated and stored in a controlled location after use.

Supervision. The supervisor of a work group or the leader of a laboratory group has the responsibility for seeing that the radiation work under his guidance is performed in a safe manner. The supervisor is required to see that the established rules regarding food handling, checks of personnel activity, waste disposal, etc., are maintained. The objective is the education of each and every worker to follow these necessary procedures for his own protection, and the protection of others. In a radioisotope laboratory, skill in radiation protection is as necessary as skill in chemical or biological manipulations. Persons failing to develop such skills should be advised to transfer to other occupations.

Laboratory Design and Equipment Required for Protection

General Working Conditions. Successful work with radioisotopes other than in true tracer amounts requires the use of laboratories and equipment specially designed for the purpose. No work should be undertaken in these rooms other than that concerned with the application of radioisotopes.

Floors. The floors must have smooth, continuous surfaces as far as possible, such as stainless steel, painted concrete, or linoleum. Absorbent floors, for example, wood, should be avoided. Asphalt tile and similar materials are permissible, provided that the laboratory supervision be aware of the hazards of accumulation of radioisotopes in the cracks. The ease of replacement of sections of tile floor compensates for the hazard of crack contamination. Floors should be cleaned daily by wet mopping, or by use of moist compound. Dry-sweeping may lead to an active dust hazard.

Walls, Ceiling, and Woodwork. Walls, ceiling, and woodwork must be finished with a nonporous washable surface, which may be cleaned to remove accumulation of radioactivity. Projecting ledges, hanging lamps, etc., which may accumulate dust should be avoided.

Ventilation. All laboratory operations with more than low level activity should be conducted in hoods which will be provided with forced ventilation sufficient to maintain the activity content of the room air below 10^{-5} microcuries per liter at any place at any time. The linear velocity of air flow should be in the range of 100 to 150 feet per minute. Specially hazardous operations; e.g., handling long-lived bone-seeking isotopes in injection or inhalation studies on animals, should be conducted by personnel wearing suitable respirators or supplied-air masks. Hoods with individual filter systems for exhaust air are preferred. Multiple hood systems are dangerous because reverse air currents may occur.

Equipment. Special equipment suitable for the type and level of activity should be provided for each type of operation. This should include handling tools such as tongs, forceps, trays and mechanical holders. Long-handled tools provide adequate protection by distance where millicurie amounts of beta or gamma activity are encountered. Semi-remote control sampling and stirring devices should be included. Operations with larger amounts require the use of specially designed, remote-control equipment including a shielded optical system (e.g., a periscope or mirror arrangements.) When the isotopes concerned are primarily beta emitters, efficient use can be made of transparent plastic shields fitting closely around the equipment to allow close handling with good visibility. Meticulous care should be taken to see that the moving parts of open centrifuges are maintained free of contamination. Covers of centrifuges handling active materials must not be open while the motor is in motion. Equipment and laboratory ware which have become contaminated should be stored in an operating hood or under water until cleaned.

Containers for the active material should incorporate the necessary shielding as close to the source as possible. Containers for liquid samples should always be reinforced by an outer, unbreakable container.

Hoods and Benches. Laboratory benches should be free from cracks, crevices, or sharp corners. Suitable surfaces for work tables are stainless steel, monel metal, and plate glass. The work surface should be covered with absorbent paper[22] to catch minor spills, and this paper should be changed after each laboratory experiment. The work in hoods should similarly be performed over an inner washable tray covered with the absorbent paper. The work bench should be equipped with wiping papers for the prompt removal of spills. Drawers in work benches, if provided at all, should be washable and have removable liners.

Storage and Handling of Contaminated Wastes from Laboratory. Waterproof disposable containers to hold the discarded absorbent bench paper and wiping papers should be provided at each laboratory station. Two trash cans painted entirely red (both top and can) should be provided at each desired location for trash which is contaminated. Only one of these two cans should be used at a time, and the one in use should be tagged: "Use this Can." It should be the responsibility of the supervisor to see that these cans are monitored at sufficiently frequent intervals to prevent active materials from accumulating to such an extent that radiation levels of greater than 12.5 mr/hr occur. Once a can has been labelled "Driver, O.K. to Pick Up," no more contaminated trash should be put in that can. When the can has been emptied and returned, the tag should be removed so that it may be held in reserve while the second can is in use.

Tools and other miscellaneous equipment used in handling long-lived isotopes should be regarded as contaminated and should not be released for other work until proved otherwise.

Quantities of plutonium greater than 1 microgram must be securely covered during storage and kept in a hood equipped with doors, or in other spaces specifically accepted by the Health Director, or his representative, as suitable under the given circumstances. All transfer of materials between hoods and storage devices must be done in such a manner as to avoid the possibility of spillage or breakage. Double containers to eliminate contamination and breakage danger should be used. Any work with materials susceptible to atmospheric distribution of plutonium[23] (that is, dusting, spillage, vaporizing, effervescence of solution, etc.) should be done in an "adequate hood."

Inspection of Work Areas.
The beta and gamma-ray exposures at points habitually occupied by workers must be determined periodically by properly designed ionization or counter devices, operated by qualified personnel. An instrument, or instruments, should be available to cover the range from 1 mr/hr up to 2 r/hr. Other meters for the qualitative detection of small amounts of active contamination should be available. Under laboratory conditions, each person in the laboratory should be responsible for maintaining an adequate frequency of inspection in his own work area. In larger organizations, it may be expedient to employ personnel specifically for these inspections. Continuous monitoring equipment, which may have an alarm feature, is suitable for locations handling "curie" amounts of radioisotopes. Such meters, and many portable survey meters, give an adequate indication of the hazard arising from contaminated surfaces. Such surfaces may give a direct contact exposure hazard, or offer a means of transfer to the body.

The instrument response corresponding to a permissible level of beta contamination is a function of the active materials involved, and each laboratory should[24] properly evaluate these levels for its own purpose. In general, if a Geiger counter of flat-plate area about 2 sq. inches be passed with a normal hand motion over a suspected surface, contamination is present in undesirable amounts if there be an obvious instrument response. This policy will result in the cleaning of some areas which were not specifically dangerous to personnel. This in general is offset by the easier definition of this particular limit, and the benefits arising from the maintenance of an extremely clean work area. Care must be taken to ensure that the test instrument used is reasonably responsive to radiations emitted by the available isotopes.

22. A "diaper" paper must be available that has a waterproof backing to reduce penetration of spills to the work surface.

23. See footnote 21.

24. It takes about 1 month to learn to read a Geiger counter adequately.

The amount of activity in the form of gas, vapor, dust, or spray in the air has to be determined routinely in the laboratory in order to be aware whether the protective measures maintained in the laboratory be conducive to preventing hazards.

Inspection of Protective Clothing. The first inspection of protective clothing should be made by the wearer prior to removal. Very active items should be discarded in closed containers as active solid waste. The remaining items should be washed and monitored under controlled conditions. Special laundry facilities should be used by all groups regularly engaged in radioisotope work. Preferred solvents for laundry rinses depend on the chemistry of the isotopes used. Where miscellaneous isotopes may be present, dilute acetic acid is recommended. Dilute nitric acid may be used on rubber items. Before contaminated garments are considered for release to public laundry service, the extent of hazard must be very carefully evaluated.

Inspection of Wastes. Responsibility should be designated for the inspection of the disposable containers for solid waste. Tests for emitted beta and gamma radiation, and in some cases for radioactive contamination of surrounding air, are required. Radiation monitoring of the assembly of these containers at a central depot may be necessary.

Monitoring and segregation of active liquid waste is similarly required. The inspection of gaseous and dust effluents, etc., is mandatory in the larger installations where such effluents may be hazardous. Tests for possible deposition and accumulation beyond the confines of the laboratory may be required. Methods sufficiently sensitive to detect radioactive contamination in air, water, or soil, are required.

An air-cooled pile, such as the one at Oak Ridge, induces activity into the cooling air and in any dust contained in the cooling air streams. Radioargon is the principal radioisotope discharged into the air, but since it is not selectively absorbed in the body, it presents a minimum hazard and is disposed of from tall stacks which give an adequate dilution factor. The radioactive dust is removed by use of filters. Continuous air samples and other measurements are taken in the neighborhood of the pile building to insure that its operation be maintained safely at all times.

Contamination of Areas. All areas in which there is radiation in excess of 12.5 mr/hr should be either roped off and appropriate signs posted to prevent persons from coming dangerously close to the radiating source, or, where the hazard is of a permanent nature, permanent signs should be posted, barricades installed and existing doors locked. Where activity levels are very high, a patrol force should be posted to prevent accidental overexposure.

Experimental work involving especially hazardous levels of activity should not be undertaken until suitable protective measures have been agreed upon.

In case of any permanent change of personnel or permanent vacating of quarters, it should be the duty of the individual and his supervisor to see that the area if properly surveyed and if necessary,decontaminated before it is vacated.

Areas or rooms which should be kept free from contamination should be posted with signs on all doors warning persons not to enter with contaminated materials or clothing.

A hood containing a high amount of plutonium[25] contamination must be clearly marked "high level hood." Hoods so designated must not be repaired or worked on without approval. The approval must specify protective measures for the personnel involved.

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25. See footnote 21.

Spills and Contamination Levels

No exposed plutonium[25] should ever be "tolerable;" the following are maximum levels which are perhaps unavoidable in some cases;

	Surface: d* per minute for 150 sq. cm. (small spots)	Smear: 2 sq. in.** counted in standard chamber	Total Contamination (large area)
Exposed surfaces, floors, bench tops, etc.	2,000 d*	0 d* per minute	14,000 d* per min./sq. ft.
Exposed but protected from handling (roped off, etc.)	10,000 d*	25 d* per minute	7,000 d* per min./sq. ft.
Inside poor or intermittently used hood	30,000 d*	25 d* per minute	280,000 d* per min./sq. ft.
Inside adequate hood, operating	(upper limit will vary with area rules and hood efficiency)		

*d stands for disintegrations

**A 2 sq. inch paper wiping a total of 12 sq. inch of tested surface.

All spills of plutonium must be cleaned up immediately unless inside of adequate hood. Cleaning responsibility should lie with the operating group in the room and area involved, and they should check after cleaning to verify that cleaning be thorough. In cases of large spills or if in doubt, a health supervisory representative should be called.

Gamma Ray Shielding Table[26]. Shield thickness for laboratory sources can be determined by the use of the Table 13. Let us suppose the following example:

An iron shield is required for the manipulation of 500 mc. of radioactive material emitting 1.8 Mev gamma rays at a minimum working distance of 50 cm., and for 2 hrs. per day.

Step 1. Select column in A part of table for energy required using the next high value if the exact value be not given in table. In this case, there is no column for 1.8 Mev, therefore the 2.0 Mev column is used. The figure corresponding to 2.0 Mev and 500 mc is +7.08. This is the basic entry.

Step 2. Correction for danger range, using B part of table. The minimum working distance is stated at 50 cm. The figure in the table corresponding to 50 cm. in column 2.0 Mev is +2.76. This is added to the basic entry + 7.08.

Step 3. Correction for working time, using C part of table. Exposure will be for 2 hrs. per day. The figure corresponding to 2 hrs. in the 2.0 Mev column is -2.70. Because it is a minus figure, it is subtracted from the basic entry.

Step 4. Correction from lead (pb) to iron (Fe), using D part of table. The figure corresponding to Fe in column 2.0 Mev is 1.53. The equation of the above 3 figures are multiplied by 1.53. The resulting figure is the shield thickness.

Resume'

Shield Thickness = (7.08 + 2.76 - 2.70) x 1.53 = 10.9 cm. of Fe

26. This table is intended as a guide to rapid erection of temporary shielding structures in a laboratory. Where permanent installations of maximum economy are planned, more detailed calculations by conventional methods are required. (Table prepared by C. C. Gamertsfelder.)

In this table, Sections A to C are given in thicknesses of lead, whereas the last Section, D, is a conversion table for other shield materials.

Table 13. Gamma Ray Shielding Table

	Activity	0.2 Mev	0.5 Mev	0.8 Mev	1 Mev	1.5 Mev	2.0 Mev	2.5 Mev	3.0 Mev	4.0 Mev
A	10 mc	-.50	-.86	-1.02	-1.05	-.83	-.61	-.39	-.13	-.23
	20 mc	-.36	-.44	- .33	- .14	+.33	+ .76	+1.06	+1.36	+1.68
	50 mc	-.17	+.09	+.59	+1.04	+1.82	+2.55	+2.95	+3.30	+3.58
	100 mc	-.03	+.33	+1.28	+1.95	+2.97	+3.92	+4.41	+4.79	+5.03
	200 mc	+.10	+.91	+1.97	+2.85	+4.11	+5.27	+5.84	+6.26	+6.47
	500 mc	+.30	+1.46	+2.89	+4.04	+5.61	+7.08	+7.76	+8.22	+8.38
	1 c	+.42	+1.86	+3.57	+4.94	+6.75	+8.43	+9.19	+9.69	+9.82
	2 c	+.56	+2.27	+4.27	+5.84	+7.87	+9.78	+10.63	+11.16	+11.25
	5 c	+.75	+2.81	+5.19	+7.03	+9.39	+11.58	+12.54	+13.12	+13.17
	10 c	+.89	+3.22	+5.87	+7.94	+10.52	+12.94	+13.98	+14.59	+14.60
	20 c	+1.03	+3.63	+6.57	+8.84	+11.67	+14.31	+15.43	+16.08	+16.06
	50 c	+1.21	+4.17	+7.47	+10.02	+13.16	+16.09	+17.33	+18.02	+17.95
	100 c	+1.35	+4.58	+8.18	+10.93	+14.31	+17.46	+18.78	+19.51	+19.41
	Danger Range	plus	plus	plus	plus	plus	plus	plus	plus	plus
B	20 cm	+.64	+1.90	+3.22	+4.19	+5.28	+6.31	+6.70	+8.68	+6.70
	50 cm	+.28	+.83	+1.39	+1.83	+2.32	+2.76	+2.93	+3.00	+2.93
	1 m	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2 m	-.28	-.83	-1.39	-1.83	-2.32	-2.76	-2.93	-3.00	-2.93
	5 m	-.64	-1.90	-3.22	-4.19	-5.28	-6.31	-6.70	-6.86	-6.70
	10 m	-.92	-2.71	-4.60	-5.98	-7.55	-9.02	-9.57	-9.80	-9.57
	Working Time	plus	plus	plus	plus	plus	plus	plus	plus	plus
C	1 hr day	-.41	-1.22	-2.08	-2.69	-3.40	-4.06	-4.31	-4.41	-4.31
	2	-.28	-.81	-1.37	-1.79	-2.26	-2.70	-2.87	-2.94	-2.87
	4	-.14	-.14	- .69	- .90	-1.14	-1.35	-1.44	-1.47	-1.44
	8	00	00	00	00	00	00	00	00	00
	24	+.18	+.53	+1.10	+1.17	+1.48	+1.76	+1.87	+1.92	+1.87
	Absorber	times	times	times	times	times	times	times	times	times
	Pb	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Fe	4.75	2.68	2.11	1.75	1.51	1.53	1.53	1.53	1.77
	Al*	17.23	7.71	5.43	5.13	4.70	4.25	4.81	5.22	6.01
	H_2O	35.00	17.80	12.50	11.15	9.93	10.00	11.20	12.35	14.10

*or concrete

Management of Radiation Accidents

External Radiation. A person presumed significantly overexposed to external radiation should be removed promptly from the hazardous area. Such a person should not be allowed to return to work involving radiation unless it be evident that radiation damage will not result. If investigation indicates that the overexposure may be serious, the exposed person should be referred to a physician qualified to ascertain the extent of the radiation injury if any.

Ingestion. Persons swallowing radioactive solutions should be treated as for poisoning. The material should be removed by an emetic or by stomach pump, and the residue rendered insoluble to reduce absorption. Addition of carrier element may be indicated. Blood samples and subsequent urine samples should be analyzed to compute the body content of contaminant. Where this approximates the maximum permissible load, radical corrective procedures are indicated. Similar protocol applies to other forms of potential intake described below.

Since plutonium produces death by causing a breakdown of the walls of veins and arteries with consequent hemorrhage, the elimination of the plutonium from the body can be accelerated by giving zirconium which displaces the plutonium. Rutin, the flavonol glucoside extracted from the buckwheat plant, has been found to prevent hemorrhage by strengthening the walls of arteries and veins.

Surface Contamination. Persons splashed with active solutions should wash the affected parts immediately, and if still contaminated, apply recognized decontaminating agents. Where the chemistry of the active solution is not immediately known, an application of titanium dioxide paste, or a saturated solution of potassium permanganate followed by a 5% sodium bisulfite solution rinse, is frequently effective. Care should be taken to ensure that no activity be left under the fingernails.

When the hand is known to be contaminated with a small spot of high specific activity, it is better not to wash the hand as this unnecessarily spreads the contamination. Such spots are removed by masking off the surrounding areas, and by cleaning the affected part with cotton applicators dipped in suitable decontaminants.

Minor Injuries. Persons cut by glassware, injured by hypodermic needles, etc., should wash the injured part under a strong stream of water. A venous-return tourniquet may be applied if the material be unusually toxic. If it be ascertained that the injury was caused by an item bearing a hazardous amount of material, a biopsy section of the wound should be analyzed. Excision of the part to reduce further body absorption may be indicated in extreme cases.

Inhalation. Persons inhaling radio-toxic fume, spray, or dust should be treated to stimulate removal of the toxic material from the lung.

Radiation Measuring Instruments

All nuclear radiation-detecting devices except photographic film devices are based upon the ionization produced in gasses by the incident radiation. The ions formed in the gas are electrical currents which are readily measured by electrical meters.

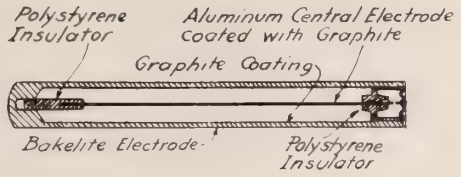
When an ionizing agent, alpha particle, beta particle, neutron, or gamma ray photon enters the gas, it may act on a neutral atom with an energy large enough to remove one or more electrons from the atom. The particle proceeds with reduced energy and may repeat the ionization process. Production of ion pairs is the most probable result of the movement of these particles. The ionization energy or ionization potential is the force needed to remove the most loosely bound electron from an atom or molecule. This has a definite value for each gas.

However, the actual energy loss to the ionizing agent is considerably higher than the ionization potential since many collisions take place without ionization, and sometimes a more tightly bound inner electron will be removed at a higher energy loss than the potential. For instance, for hydrogen the ionization energy is 15.4 ev, the energy loss per ion pair is 32 electron volts. Average loss is 33 ev. Thus, an incident particle having an energy of 1.5 Mev will produce in air $\frac{1.5 \times 10^6}{33} = 4.5 \times 10^4$ ion pairs.

Ionization Currents. If the formation of ions occurs in an electric field, the field will exert a force on each ion and they will move in opposite directions: the negative ions toward the positively charged anode and the positives to the negatively charged cathode. The voltage applied to the electrodes, the nature of the ions, and the gas pressure are factors determining the speed of the ions which will be neutralized at the poles and remove the charge from the battery. This results in a (small) current flow through the battery and the external circuit. It can be figured that when 100 alpha particles enter the gas per second, the resulting current would be in the magnitude of 10^{-13} amperes. Since the best laboratory galvanometers are sensitive to 10^{-10} amperes only, and portable microanometers to 10^{-6} amperes, the ordinary current measuring instruments are inadequate, and therefore special instruments had to be designed in which these currents are amplified.

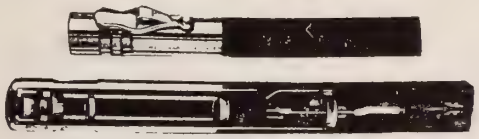
When a constant amount of ionization is produced, as by a constant intensity X-ray beam, and the ionization current is measured for various electrode voltages, it will be seen from the Fig. 7 that the current at first increases directly with the potential, then lags more and more behind. With low voltage, only part of the ions reach the electrodes; this number increases until finally all ions reach them and the current remains constant. This maximum current is called saturation current.

RADIATION MEASURING INSTRUMENTS

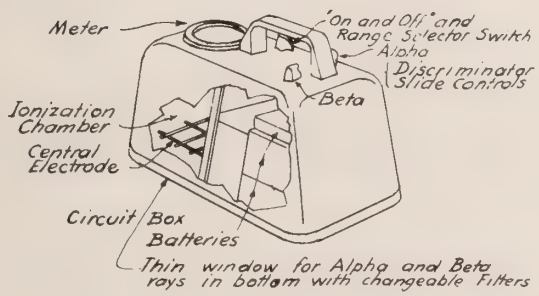


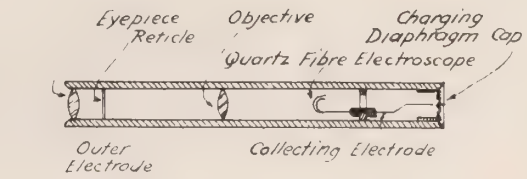
1. PERSONNEL POCKET CHAMBER

Used for determining the radiation exposure of personnel and carried in the pocket like a fountain pen It is charged to a known potential at the start of the working day At the end of the day the potential is measured with an electrometer From the loss in potential the total radiation received can be determined
Scale range : 0.2 r ; 10 r ; 50 r, 100 r



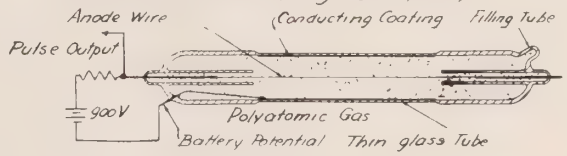
3. CHAMBER AND DOSIMETER



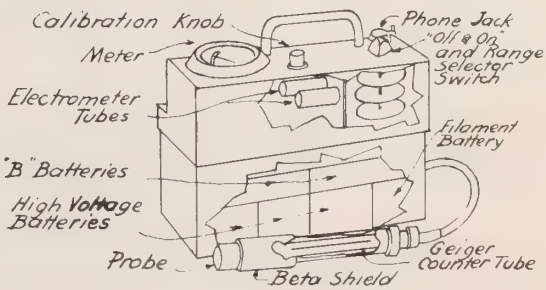


2. POCKET DOSIMETER

Used for the same purpose but is self-reading and needs no electrometer When the meter is charged the metal-coated quartz fiber fully diverges from the electrode and at this position its image on the reticle is made to read zero Ionization thru radiation will cause the gap between the wires to close slowly, and its position at any time shows total rad. up to that time Scale range 0.2 r , 10 r ; 50 r



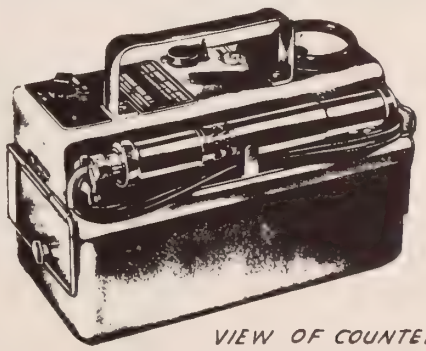
4. GEIGER TUBE



5. AREA SURVEY METER
FOR ALPHA, BETA, AND GAMMA RADIATION

The electrodes in this instrument are connected to a battery which constantly rectifies any drop in potential due to ionization. The ionization current thus created in the circuit is a measure of the radiation dose rate and is measured with the aid of vacuum tube amplifiers
Scale range : 0-40,000 d/m for Alpha and 0-25 mr/h for Gamma, and higher in special meters

6. GEIGER-MUELLER COUNTER
FOR GAMMA AND BETA RADIATION



VIEW OF COUNTER

GEIGER-MUELLER COUNTER (4. & 6.)

The Geiger Counter is the most convenient monitoring instrument for Beta-Gamma ray detection It is extremely sensitive and the better instruments have both meter and earphones. As it is about 100% effective for Beta and only 1% for Gamma rays it should not be used for quantitative measurements although it can be calibrated in mr.p.h for a particular Gamma ray distribution.
Usual range : 0-20 mr.p.h. with range switch factors of 1, 0.1, 0.01 corresponding respectively to 150,000, 15,000, and 1,500 counts per minute for Radium Gamma
The principle of the instrument is the application of high voltage to a small ionization tube so that by "avalanche" ionization, when a ray hits the tube, even one single ion pair can produce an amplified (and audible) pulse of the same size as obtained from a large number of primary ions. The discharge can be quenched either by the use of polyatomic gas in the tube at 10 c.m mercury pressure or by a quenching circuit Higher intensity in radiation is indicated by a higher pulse count per minute and a higher reading on the current output meter

JAKW

Fig. 8 Radiation Measuring Instruments

When voltage is low and velocities are low, there is always the tendency of oppositely charged particles to recombine and reform neutral atoms. At saturation the velocity is so great that no recombination be possible. It is evident that in the saturation region the current is independent of the electrode voltage —once this has a high enough minimum —and fluctuations in this voltage will not affect the current readings. This is particularly important in portable instruments where it is not possible to incorporate elaborate voltage regulation circuits and where the battery voltages will decrease with use.

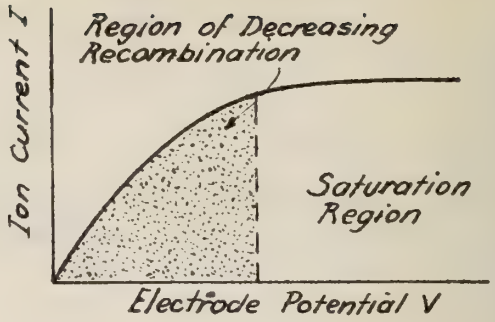


Fig. 7

It is also evident that an ion while on its way to the electrode will increase its energy unless it loses energy through elastic collision with gas molecules (part of the kinetic energy is given to these molecules). If the gas be at atmospheric pressure this energy loss will be great; the mean free path of the gas molecules is small. Reduction of the gas pressure from atmospheric to 10 cm. of mercury will increase the mean free path from 10^{-6} cm. to 10^{-4} cm., or a hundred times larger. If the mean free path be increased by using a partial vacuum, and if the applied voltage be high, the ion will gain a greater energy between collisions. If this energy becomes greater than the ionization energy of the gas molecule it may produce secondary ions upon collision. In this type of collision the total kinetic energy is not conserved and the collision is inelastic. These secondary ions may, in turn, be accelerated by the electric field and produce further ionization. This accumulation affect is called townsend or avalanche ionization. If a total of A ion pairs results from one original pair, the number A is called the gas amplification factor. In practice, A varies from about 10 in gas filled photoelectric cells to 10^8 in some Geiger-Muller counters.

Monitoring Instruments. For the measurement of radiation intensities of atomic-bombed premises, of nuclear waste products, of uranium lodes, etc., several portable instruments have been designed. All instruments should be maintained in calibration by trained technical personnel.

Personnel pocket chamber (Fig. 8-1 and 3) This instrument has the form and size of a fountain pen, and is similarly carried in the pocket. It consists of an outer tube of bakelite with an inside graphite coating; in this tube is placed centrally, an aluminum electrode likewise coated with graphite. The instrument is used for the protection of personnel subject to radiation. At the start of the working day the pocket chamber is charged to a known potential; at the end of the day the resulting potential is measured, and from the loss potential the total radiation received can be calculated. Capacities are 0.2r, 10r, 50r, and 100r (roentgen).

The Pocket Dosimeter. (Fig. 8-2 and 3) Whereas an electrometer is needed for the reading of the pocket chamber, the pocket dosimeter which is also carried like a fountain pen is self reading. In this instrument also, a difference of potential is applied between the case, acting as one electrode, and a central wire; for the other electrode, the dosimeter has attached to it a metal-coated quartz fiber which acts like the gold leaf of an electroscope. When the dosimeter is charged, the quartz fiber diverges from the wire and the position can be read on a calibrated scale. The more that ions are collected, the less the diversion of the quartz fiber which can be observed by means of a small compound microscope fixed into the opposite end of the chamber.

Film Badges. Pocket chambers should be supplemented by a film badge which contains film partially covered by a suitable metallic filter such as one millimeter of silver or cadmium. Blackening of the film in the shielded area is then approximately independent of the energy of the gamma radiation (above 80 Kev.) Blackening of the unshielded portion may be due to beta radiation or gamma radiation, especially low energy gamma radiation. Such film badges give a sufficiently quantitative record of the integrated weekly gamma-ray dose. The beta-ray dose can be obtained quantitatively when exposure to soft gamma radiation is excluded. Special film packets containing two films of different sensitivity are available for badge monitoring. Sensitive film is effective in the range of 25 mr to about 5 r. The insensitive film is effective up to about 40 r. and is read only in the event of a major exposure.

It has been found that potassium bromide crystals which have been activated by heating in sodium vapor change from their normal colorless state to blue in the presence of gamma radiation. Dosage may be determined by comparing the color with a series of standards. At present this application is limited for rather high intensities of radiation, such as 50 roentgens or more.

There is available a self-developing film badge dosimeter. Sensitized film and chemicals are contained in a small metal case. Radiation exposure can be rapidly determined by merely pulling out the film pack, waiting a minute, and then comparing the color-shades from black to white with six standard shades printed in scales along each edge of the film. In contrast to previous film dosimeters, this film is a positive, i.e., white is exposed, black is unexposed.

A phosphate glass which undergoes a change in fluorescent properties has also been developed. After the glass disk, which is about the size of a quarter, has been exposed to radiation, its fluorescence under untraviolet light is measured and related to the dosage received.

Finger Rings. Workers who manipulate radioactive solutions or handle sources should wear film rings or other suitable devices on the finger to estimate the hand exposure. Rings which include the metal shield with open window can be used. In many cases, a simple film disc covered with thin rubber is an effective substitute which introduces very little inconvenience in handling laboratory tools.

The Geiger Tube. (Fig. 8-4) The Geiger tube is used in the Geiger-Muller counter to measure gamma and beta radiation, and act as neutron detector. In the picture the glass tube, preferably filled with a poly-atomic gas of 10 cc. mercury pressure, has a conductive coating to act as cathode; the anode wire is placed centrally and connected to the anode of the battery. Gas amplification can be obtained at 250 to 1500 volts, depending on the gas and the tube dimensions. This anode wire is very thin, from 0.001" to 0.005" in diameter. Another type of cathode is a copper cylinder placed centrically with the anode and spot-welded to the heavy tungsten lead connected to the battery. A Geiger tube is, in fact, only a small, specialized, ionization chamber in which an electrical current is created with a high acceleration voltage.

An ionized particle entering this chamber will produce a definite number of ion pairs in the tube, producing a pulsation in the external current. (If there be a large number of these pulsations per second they will appear on the meter as a steady current.)

If the voltage remains below a certain limit, the only ions contributing to the pulse will be those produced by the original radiation. (See Fig. 9 B)

If the voltage increases, the acceleration of the ions toward and near the central wire will create a gas amplification called "avalanche ionization" near the central wire, and there will be a definite amplification factor for the given voltage (Fig. 9 C). This part of the curve is called the region of proportionality and a tube operating in this region is called a proportional counter. Such counters can be used to measure alpha particles and neutrons in the presence of strong beta and gamma radiation. When the voltage increases, some proportionality remains (D) until finally all proportionality is lost. Here a single ion pair is sufficient to produce an amplified pulse of the same size as that obtained from a large number of primary ions. This region, known as the Geiger region, is used for counting beta and gamma radiation characterized by gas amplification factors of 10^8. As all ionization events result in the same pulse sizes, the range of ionizing power, so different in beta particles, is of no consequence.

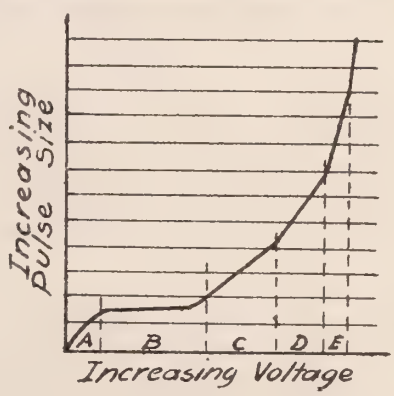


Fig. 9. Relation of Pulse to Voltage

As has been pointed out, the first avalanche will occur close to the central wire and the electrons will be collected here in a micro-fraction of a second or less. The positive ions will move slower toward the cathode and have a longer way to travel, reaching it in 10^{-3} seconds, or com-

paratively long after the electrons have been neutralized. When such a positive ion approaches quite close to the cathode it will pull an electron from it and will be converted to a neutral atom. As the electron will go into one of the outer orbits, the atom, although neutral, will be excited. If enough, a single liberated photoelectron may start a new avalanche. If the number of pulses per second be drawn in relation to the voltage, it will be seen that a certain minimum voltage is needed to produce a pulse, and that in the "Geiger region" CD (Fig. 10) the number of pulses remain practically constant for a certain radiation. Tubes are made which show only a count difference of 1% for a change of 100 volts. This part of the curve is called the "plateau" and it is obviously desirable for a Geiger tube to have a long, flat plateau. Filling gas and pressure must be well chosen, and the metal parts or coatings must be smooth. Oxygen and water vapor must be completely removed. With small central wires and special filling gases, the center of the plateau may lie at 250 volts instead of the usual 800 to 1200 volts, but as the length of the plateau is also reduced the voltage adjustment is more critical.

Quenching. With argon or any diatomic gas, a single discharge will be self perpetuating by photoelectric effect at the cathode (explained above) even when the voltage is set at the center of the Geiger region. This can be prevented by placing a very high resistance, such as 10^9 ohms, as a series resistance, between the battery and the tube. A pulse of 10^{-7} ampere (0.1 micro ampere) will cause a voltage drop of 100 volts. The resultant decrease in gas amplification factor will prevent a second avalanche. A disadvantage of this method is the current-change delaying effect due to the high resistance; thus the counter will be "slow." For this reason other condensor arrangements have been made to avoid this disadvantage by using condensors and vibrators. Discussion of these various circuits is beyond the scope of this chapter.

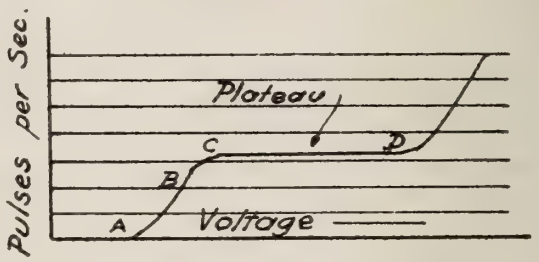


Fig. 10. Geiger Tube Characteristics

Self-quenching tubes. A self-quenching counter can be produced by adding to the usual filling gas a small amount of poly-atomic vapor such as alcohol or xylene. These complex molecules have strong absorption for ultra-violet light, preventing the photo-electric emission at the cathode. With such filling, the series resistance may be taken 1000 times lower (10^6 ohms) with corresponding decrease in the recovery time of the tube. Some of the quenching gas, however, is broken down with use, and with long use the tube will become erratic.

Geiger counter efficiency. Since argon produces a high number of ionizations per cm. of path length of the ionizing particle, it is evident that any beta ray will initiate an impulse, and therefore the efficiency is 99% for beta rays (of those penetrating the tube wall.) A gamma ray, however, is detectable only by the electrons it produces in the counter wall or in the gas, and the probability of producing any of these electrons is low (about 1%). The alpha particle efficiency, in contrast, is 100% of those which penetrate the tube wall.

The Geiger tube is used in the Geiger-Muller counter. Inside and outside arrangements are shown in Figs. 8-4 and 6. Usually head phones are used and the degree of radiation is determined by the number of impulse "clicks" produced by the amplifier per minute. The counter can be shielded off for alpha and beta rays if so desired. The Geiger-Muller counter is the most convenient portable instrument for gamma ray detection.

Area Survey Meter. (Fig. 8-5) The area survey meter of the type shown in the figure is one with which all types of radiation can be detected and measured. It is a portable instrument with a large ionization chamber and electrode grid. The base contains a thin window for alpha and beta rays, with absorbing screens. The other part of the box contains batteries for the circuit current and the electrometer amplifier. It is very useful as a general survey meter; dimensions 5 x 6 x 12"; weight 9 pounds. It is, of course, much less sensitive than the Geiger-Muller counter.

Radiation as a Function of Time.

The intensity of radiation declines at first rapidly, then slower and slower. There is a mathematical relationship between radiation and time which can be expressed as $It^n = K$ in which I is the intensity of radiation in roentgen per day at time t; n is an exponent which is 1.2 for beta and gamma rays and 1.6 for the other radiation, t is the time in days, hours, or minutes (usually

hours) after the accident or atomic explosion. K is the intensity of radiation after unit time (usually 1 hour) after the accident or explosion.

In monitoring activity, in time of war, when it is often necessary to reach vital stores in a badly damaged area contaminated with heavy radiations, this formula is used to determine the time which has to elapse before the stores can be removed by manual labor, in consideration of tolerance for short exposures (maximum permissible exposure for external total body radiation.)

An example of the use of this equation is as follows: In a laboratory room, a tube containing radioactive liquid has been shattered, and the liquid splashed over work tables and floor. The room was at once deserted and locked pending radiation investigation. 24 hours later (1 day) the radiation was measured with an ionization chamber designed for high intensity radiation and found to be 200 roentgen per day. Seventy-two (72) hours after this measurement another one was made, and it was found that the radiation had dropped to 21.8 roentgen per day. Assuming that it is desirable to delay the decontamination work until the radiation has dropped to 1 roentgen per day, how long will this delay be?

The first measurement I_1, after 1 day, was 200 roentgen per day. Therefore, this is also equal to K.

The second measurement I_2, after 4 days was 21.8 roentgen per day. Therefore:

$$I_2 t_2^n = K = 200$$

$$21.8 \times 4^n = 200$$

$$\log 21.8 + n \log 4 = \log 200$$

$$n = \frac{\log 200 - \log 21.8}{\log 4} = \frac{2.30103 - 1.33845}{0.00200} = 1.6$$

When I = 1:

$$1 \times t^{1.6} = 200$$

$$\log t = \frac{\log 200}{1.6} = 1.4381$$

$$\text{or } t = 27.4 \text{ days needed}$$

Another Example:

In a warehouse in a badly damaged area are 1,000 cases of urgently needed supplies. Men sent in with monitoring instruments 60 hours after the A bomb explosion find a maximum of 33 roentgen per day (r.p.d.) equivalent to 1.4 roentgen per hour (r.p.h.) For a 10 hour work day the dosage would be 14 roentgen, which is permissible for one day (for the purpose, for example, for getting a sample of the supplies) but if continued would cause radiation sickness.

Assuming the permissible radiation to be 1 r.p.d. or 0.1 r.p.h. for a 10 hour work day, how long must we wait? The decision to delay was made 61.5 hours after the explosion.

$$I = 1.4 \text{ r.p.d.}$$
$$t = 60 \text{ hours}$$
$$n = 1.2 \text{ for uranium and plutonium fission}$$

$$K = It^n$$
$$K = 1.4 \times 60^{1.2}$$
$$\text{Log } K = \text{Log } 1.4 + 1.2 \text{ Log } 60$$
$$\text{Log } K = 0.14613 + 1.2 \times 1.77815$$
$$\text{Log } K = 0.14613 + 2.13378$$
$$\text{Log } K = 2.27991$$
$$K = 190.5 \text{ roentgen}$$

Where I = 0.1 r.p.d., the formula would give:

$$\text{Log } K = \text{Log } 0.1 + 1.2 \text{ Log } t$$
$$\text{Log } t = \frac{\text{Log } K - \text{Log } 0.1}{1.2}$$
$$\text{Log } t = \frac{2.27991 - (-1)}{1.2} = \frac{2.27991 + 1}{1.2} = \frac{3.27991}{1.2} = 2.73325$$
$$t = 541.0 \text{ hour}$$

Therefore 541 hours, or about 3 weeks of waiting will be required. This is too long. It was therefore decided to get enough workers to limit each working day to 4 hours, and to double the maximum daily allowable dosage to 2 roentgen, thus changing the r.p.h. to 0.5.

Therefore:

$$K = 0.5\, t^{1.2}, \text{ where } I = 0.5 \text{ r.p.d.}$$

$$\text{Log } K = \text{Log. } 0.5 + 1.2 \text{ Log } t$$

$$\text{Log } t = \frac{\text{Log } K - \text{Log } 0.5}{1.2}$$

$$\text{Log } t = \frac{2.27991 - (9.69897 - 10)}{1.2} = \frac{2.27991 - 0.69897 + 1}{1.2}$$

$$\text{Log } t = \frac{2.58094}{1.2} = 2.15078$$

$$t = 141.5 \text{ hours}$$

Since 61.5 hours have already passed, 80 more hours or 3 1/3 days must pass before starting to work.

Waste Disposal

Disposal of Gaseous Wastes produced in the following processes:

1) Material Processing. Preliminary preparation of metallic ores requires such operations as drying, crushing, grinding and sieving. Radioactive and toxic dusts are removed from the working space and the atmosphere by ordinary industrial types of mechanical separators, electrostatic precipitators, and filters. In the chemical processing of ores the fumes, mists, and gasses are removed by ventilation, scrubbing and filtration before release to the atmosphere.

2) Metallurgy and Machining. During the metallurgical and machining operations of such metals as beryllium and uranium, contaminating fumes and dusts of the metallic oxides may develop. These are removed by ventilation and filtration.

3) Air-cooled Reactors. Some constituents of the air(which is used for cooling a nuclear reactor or pile) become radioactive but their concentration is low and the half-lives short, the significant components being argon-41 with a half life of 110 minutes and occasionally carbon-14. The impurities in the air (also true for water) do not become radioactive merely by being close to radioactivity. It is necessary for these impurities to be bombarded by neutrons for radioactivity to be induced. Under abnormal conditions, uranium oxide and radioactive fission products may also contaminate the cooling air. These materials may be removed by filtration and electrostatic precipitation. The best practice is to filter the air before and after delivery to the pile. The stack through which the air is dispersed to the atmosphere should be high, probably around 300 feet, and should be released only when meteorological conditions are favorable for efficient dilution and dispersion. The future may bring forth a closed-cycle cooling system which will not discharge gaseous wastes to the atmosphere.

4) Chemical Separation. The separation of fission products from the plutonium and unused uranium after the operation in the pile is accomplished by a variety of chemical processes. The equipment is largely automatic and operated by remote control. Provision is made to remove radioactive particles which might contaminate the atmosphere by scrubbing and filtering and dissolver-off gasses.

5) Laboratory Research. High level working areas in laboratories are usually kept separate from low-level and so-called clean areas. The areas are served by separate ventilating facilities. Inlet and exhaust air is filtered and monitored regularly. In laboratories with high level activity, actual work is done in special sealed boxes set in ventilated hoods. Manipulation of radioactive materials and equipment is carried on with protective gloves or by remote control.

6) Incineration. Burning of radioactive wastes and by-products can be carried out only if provision be made to decontaminate the products of combustion. This is not a simple task. To attain effective incineration, the following problems must be solved:

a) Development of more effective filters and filter materials.
b) Better methods of removal of iodine from dissolver-off gasses.
c) Processes for bottling up of rare gasses.

d) Development of an improved incinerator.
e) Better mechanical and electrical decontaminating facilities.
f) Methods for more precise determination of particle sizes.
g) Standardization of sampling techniques.
h) Improvement of measuring instruments.

A method of air contamination control that offers considerable promise for certain operations is isotopic dilution, for example, if radioactive carbon dioxide be discharged up a stack it should be diluted and mixed with a sufficient amount of ordinary carbon dioxide.

Disposal of Liquid and Solid Wastes

In the disposal of liquid and solid wastes a monitoring program should be set up for:

1) Routine checking of water supplies, streams, lakes, etc.
2) Routine checking of burial grounds and other areas where contaminated wastes are held or disposed of.
3) Emergency warnings when radioactive contamination becomes dangerous.

Liquid waste may be disposed of by:

1) Cribbing, lagooning, or storing in underground tanks until the short-life radioactive contaminants have dissipated enough to warrant emptying into natural bodies of water with adequate dilution factors. If too much long-life radioactive contaminants be present, storage must be longer, or attempts made to separate out these substances from the liquid.

2) Concentration of radioactive materials by:
a) Evaporation: This is feasible but the process is laborious and expensive.
b) Use of resins (still experimental).
c) Coagulation, sedimentation, and sand filtration. This poses the problem of how to dispose of sludge and control radioactivity that is built up in the filter bed.

The tendency of certain radioisotopes to concentrate downstream as a result of biological, physical, and chemical factors should be checked in order to provide safety factors. Some of the factors that have the tendency to concentrate these materials are:

1) The presence of algae and other types of vegetation.
2) The presence of certain types of soils as various forms of clay or the volcanic ash which may have selective action on radioisotopes.
3) The general tendency of soil to filter out insoluble radioactive substances.
4) The effect of evaporation.

Whenever possible, the active principal in the waste solution should be precipitated and discarded as active solid material. The disposal of liquid wastes through a regular drainage system creates the problem of radioactive slime accumulations in the plumbing. The slime can safely be removed by a plumber if he protects his hands with rubber gloves. If liquid flushable waste be disposed down a sink, the radioactivity of the material should be less than 0.1 millicuries per flush, and not more than a total of 5 millicuries per week. The trap should be monitored weekly to make sure that the background radioactivity remains below the tolerable level of 0.01 r per eight hour day. How sewer systems and the biological processes common to sewage treatment will be affected still needs to be determined.

Urine from isotope-injected animals or patients, and liquors from equipment or clothing decontamination may require attention as active solutions. Solid wastes such as useful material, instruments, containers, and equipment are decontaminated and reclaimed where possible, otherwise they are buried in carefully selected burial ground. Waste material from ore may contain some radioactive material. That which can be reclaimed is processed. The remainder, if low in radioactivity, is buried; if high in radioactivity, is stored in well shielded containers until the activity has declined, and then is subsequently buried. The burial area is fenced and restricted. Earth cover of 10 to 12 feet usually assures adequate shielding. The areas are monitored regularly. Certain waste materials are encased in large steel drums which are disposed of by dumping at sea miles off shore, or buried in shielded containers or stored in underground tanks. Contaminated trash is disposed of by burial or incineration. Research is being done at present to develop a closed-cycle incinerator that will absorb the radioactivity rather than dispel it to the atmosphere. Wastes contaminated with long-life radioactive material may be encased in concrete blocks and buried or dumped off shore. Uranium bearing wastes are segregated and stored indefinitely.

Contaminated buildings present a problem. They are being disposed of by a preliminary attempt at decontamination; then they are painted, taken apart board by board, and finally buried.

When radioactive wastes are disposed of onto or into the ground or into bodies of water, the resulting contamination poses important problems to the water-works designer and the treatment plant operator. Careful consideration must be given to the character of the wastes, the geological formation of the earth, and the rate of flow and dilutions factors of the ground water in the area.

Thermal Pollution of Waters. Production of radioactive materials and the operation of nuclear power plants requires large amounts of water for cooling. The discharge of these cooling waters is expected to raise the temperatures of the receiving waters to levels harmful to fish and shell-fish and eventually, if not controlled, to industrial and other uses. Such pollution must eventually be controlled.

Possibilities of Disposal by Biological Treatment. Muds and biological flora and fauna of the discharge ponds and streams show that these components absorb some of the radioactive constituents and thus serve as concentrators. Algae and other aquatic plants may grow prolifically in water that has considerable radioactivity. Radioactive materials accumulate in plankton without affecting the plants unfavorably. This suggests the use of a controlled microflora and fauna for absorption and concentration of radioactive waste products, particularly those with long half-lives.

A modification of the activated sludge process shows promise for treatment of radioactive wastes. When the bacterial cell membranes are swollen through the absorption of water they present an enormous surface area capable of holding radioactive materials. Experiments indicate that more than 95% of a long half-life alpha emitter such as plutonium or uranium up to 1.4 micrograms per liter may be successfully removed from the liquid and transferred to the sludge. There are indications that a two-stage activated sludge process can be expected to remove 99% of plutonium from wastes, and produce an effluent that should approach a tolerance limit of 0.01 micrograms per liter. Whether or not such a process will apply to other types of radioactive materials must be determined. In many areas where radioactive wastes are found, adequate sewage (for bacterial food) is not available and methods for feeding bacteria artificially must be developed. Biological concentration methods appear to be considerably less expensive than chemical methods for removing radioactive contaminants from liquid.

The concentration of radioactive materials by aquatic organisms poses many unsolved problems. The nature of such concentration processes must be understood. For example, if radioactive materials be concentrated by algae, which are in turn used as food by snails, the latter being consumed by fish, and fish by man, it might become dangerous for man to eat fish. But luckily the radioactive materials are concentrated in the bony structures of the fish which are not usually consumed by man.

Transportation

Movements in the Laboratory. Each laboratory or institution should have a central controlled storage location for incoming isotope shipments. The minimum amounts of active material necessary for the intended processing should be withdrawn from this store, and any excess returned promptly after the operation. Movements of millicurie or greater amounts should be governed by written transfers. Each laboratory supervisor is then aware of the total activity problem in his group. Transfers from the central store to each laboratory should be made in properly shielded containers, and liquid shipments should be protected against spills. Within the laboratory, the active material must be kept in a specified safe work place. Transfers from one place to another should be reduced to a minimum, and when necessary should be made with shielding adequate to protect all personnel in the laboratory. The general rules for such shielding may be deduced from the regulations prescribed for the shipment of isotopes outside the laboratory.

Sufficient protective means for material shipped by special truck or car should be used to prevent radiation levels greater than 50 mr/hr at the rear wheels of the truck or car and to prevent levels at the truck cab or driver's seat of a car in excess of 100 mr/day for any persons in the car or cab.

Shipment of Isotopes. The shipment of radioisotopes should be made in accordance with the regulations of the Interstate Commerce Commission, and with any further specific restrictions of authorized distributors of radioactive material as described below. The formal regulations cover interstate rail, truck and water transportation. Transportation by air operates under an interim arrangement.

Shipping Rules

The Interstate Commerce Commission requested the Bureau of Explosives, Association of American Railroads to formulate regulations for adoption. The bureau was assisted by the Subcommittee on shipment of Radioactive Substances of the Committee on Nuclear Sciences of the National Research Council. The regulations became effective January 21, 1948. The following is an excerpt of those rules that will apply to expected shipments of radioisotopes.

Maximum Limits of Shipments

Not more than 2 curies of radium, polonium, or other members of the radium family and not more than 10^{11} disintegrations per second of all other radioactive materials may be packed in one outside container for shipment by rail express except by special arrangements and under conditions approved by the Bureau of Explosives.

Exemptions from Packing, Labeling and Marking Requirements

Radioactive materials are exempted from prescribed packing requirements provided they fulfill all of the following conditions:

1) The packing must be such that there can be no leakage of radioactive materials under conditions normally incident to transportation.

2) The package must not contain more than 0.1 millicure of members of the radium family or the equivalent amount of plutonium, and not more than 5×10^6 disintegrations per second of strontium-89, strontium-90 or barium-140, or 50×10^6 disintegrations per second of any other substance.

3) The package must be such that no significant alpha or beta radiation be emitted from the exterior of the package, and the gamma radiation at any surface of the package must be less than the equivalent of 10 milliroentgens of radium gamma radiation filtered through 1/2 inch of lead for 24 hours.

Packing and Shielding

Special Hazards: Radioactive materials which present special hazards due to their tendency to remain fixed in the human body for long periods of time (i.e., radium, plutonium, strontium) must, in addition to the packing described below, be packed in inside metal containers, specification 2R, or other containers approved by the Bureau of Explosives. Quantities and materials considered under this heading will be determined by the Bureau of Explosives.

Packing and Shieldings: 1) All radioactive materials must be so packed and shielded that the degree of fogging of undeveloped photographic film under conditions normally incident to transportation (24 hours at 15 feet from the package) will not exceed that produced by 11.5 milliroentgens of radium gamma rays filtered by 1/2 inch of lead.

2) The design and preparation of the package must be such that there will be no significant radioactive surface contamination on any part of the container.

3) The smallest dimension of any outside shipping container for radioactive materials must not be less than 4 inches.

4) All outside shipping containers must be of such design that the gamma radiation will not exceed 200 milliroentgens per hour or equivalent at any point of readily accessible surface. Containers must be equipped with handles and protective devices when necessary in order to satisfy this requirement.

5) The outside of the shipping container for any radioactive material, unless specifically exempt from packaging requirements, must be a wooden box, specifications 15A or 15B, or a fiberboard box, specification 12B (Bureau of Explosives,) except that equally efficient containers may be used when approved by the Bureau of Explosives.

6) Radioactive materials which emit gamma rays must be packed in suitable inside containers completely surrounded by a shield of lead or other suitable material of such thickness that at any time during transportation the gamma radiation at one meter from any point on the radioactive sources will not exceed 10 milliroentgens per hour for hard gamma rays, or that amount of radiation which will have the same effect on film as 10 mr per hour of radium gamma rays filtered through one half inch of lead. The shield must be so designed that it will not open or break under conditions normally incident to transportation, and must be sufficient to prevent the escape to the exterior of the outside shipping container of any corpuscular electrically charged radiation.

7) Radioactive materials which emit only corpuscular electrically charged particles must be packages in suitable inside containers completely shielded so that at any time during transpor-

tation the radiation measured from any point on the shipping container will not exceed the following limits:

a) 10 milliroentgens per hour for hard gamma rays, or that amount of radiation which will have the same effect on film as 10 milliroentgens per hour of radium gamma rays filtered through 1/2 inch of lead.

b) Electrically charged corpuscular radiation which has the same physiological effect as 10 milliroentgens per hour of gamma rays.

When more than one type of the above radiations is present, the radiation of each type must be reduced by shielding so that the total emission does not exceed that of paragraphs (a), and (b). The shielding must be designed so as to maintain its efficiency under conditions normally incident to transportation.

8) Liquid radioactive materials must, in addition, be packed in tight glass, earthenware, or other suitable inside containers. The inside container must be surrounded on all sides and within the shield by an absorbent material sufficient to absorb the entire liquid contents and of such nature that its efficiency will not be impaired by chemical reaction with the contents. If the container be packaged in a metal container, Specification 2R, or other container approved by the Bureau of Explosives, the absorbent cushioning is not required.

9) Radioactive materials emitting electrically charged particles only must be packed in suitable inside containers completely wrapped and/or shielded with such material as will prevent the escape of primary corpuscular radiation to the exterior of the shipping container, and the secondary radiation at the surface must not exceed the equivalent of 10 milliroentgens of radium gamma rays filtered through 1/2 inch of lead in 24 hours.

10) Empty Shipping Containers: All containers and accessories which have been used in shipments of radioactive materials, when shipped as empty containers, must be sufficiently free from radioactive contamination, that there be no significant alpha or beta radiation[27] at the surface, and the gamma radiation at any surface shall be less than 10 milliroentgens for 24 hours.

Labeling and Marking of Packages

Each outside container of radioactive material which emits gamma rays or gamma rays plus electrically charged corpuscular rays, unless specifically exempt, must be labelled with a label, red letters on white background, with design and wording as prescribed by the Bureau of Explosives. Each outside container of radioactive material which emits corpuscular electrically charged particles only must, unless specifically exempt, be labelled with a label, blue letters on white background, as prescribed.

(end of paraphase of I. C. C. regulations)

Amendment to the Postal Laws and Regulations. Radioactive Material —When Mailable. THE POSTAL BULLETIN, Washington, Page 2, April 19, 1949.

Section 588, Postal Laws and Regulations, as amended, is further amended by the addition of paragraph 6 to read as follows:

"6. Radioactive materials (liquid, solid, or gaseous; manufactured articles such as instrument or clock dials of which radioactive materials are a component part; luminous compounds; ores and residues) which fulfill all the following conditions shall be accepted for mailing provided they be properly packed in a strong tight outside container and marked 'Radioactive Material - Gamma Radiation at Surface of Parcel Less than 10 Milliroentgens for 24 hours —No Significant Alpha, Beta or Neutron Radiation.'

"(a) The package must be such that there can be no leakage of radioactive material under conditions normally incident to transportation in the mails in sacks.

"(b) The package must contain not more than 0.1 millicurie of radium, or polonium, or that amount of strontium-89, strontium-90 or barium-140 which disintegrates at a rate of more than 5 million atoms per second; or that amount of any other radioactive substance which disintegrates at a rate of more than 50 million atoms per second.

27. By "significant" radiation is meant about 500 alpha disintegrations per 100 cm^2 per minute, or about 0.1 mrep/hour of beta radiation.

"(c) The package must be such that no significant alpha, beta or neutron radiation is emitted from the exterior of the package and the gamma radiation at any surface of the package must be less than 10 milliroentgens for 24 hours.

"(d) The design and preparation of the package of radioactive material must be such that there will be no significant radioactive surface contamination of any part of the container. Liquids must be packed in tight glass, earthenware or other suitable inside containers surrounded by an absorbent material sufficient to absorb the entire liquid contents and of such nature that its efficiency will not be impaired by chemical reaction with the contents."

(Note. The amounts of radioactive materials shown are based on exemptions to I. C. C. Regulation 367, while packaging requirements are based on I. C. C. Regulation 368)

Additional Information

Besides the above data, the sanitarian should become acquainted with the various handbooks from the National Bureau of Standards. Especially:

Handbook H-23, Radium Protection
Handbook H-41, Medical X-ray Protection
Handbook H-27, Safe Handling of Radioactive Luminous Compound

Also the "International Recommendations for X-ray and Radium Protection revised by the Fifth International Congress of Radiology in September 1937, and by the Sixth Congress in July 1950.

Although much of the detail of these handbooks are already given in this chapter, there are specialized details not here given which a knowledge-seeking sanitarian would wish to master.

References:

1. Public Exposure to Ionizing Radiation, American Public Health Ass., 1958.
2. Background Material for Development of Radiation Protection Standards, Federal Radiation Council, Sept. 1961.
3. Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, National Bureau of Standards, Handbook 69, June 1959.

Statistics as an Instrument of Epidemiology for the Sanitarian

General

The whole purpose of environmental hygiene is to make the environment a most healthful and safe place to live —to prevent disease, promote health, and to prolong life. To do this effectively we must have basic information on where the reservoirs of pathogens are, how the pathogens spread, and what precisely are the effects of specific physical and social factors on human beings. Such knowledge builds the science of public health of which environmental hygiene is a most fundamental part; it creates the theoretical basis which serves as an instrument to guide us in how to manipulate and modify our environment for protecting our health, and how to measure the effectiveness of what we do. The purpose of this book is to give the sanitarian this theoretical background so he may be able to act with confidence in meeting routine and special problems. Epidemiology is the theoretical basis of public health. That phase of epidemiology which deals with the environment is the special concern of the sanitarian. Epidemiological knowledge is developed by the collection of information, and organizing this information so that it gives a picture of what is happening in relation to our health. Some of the data collected leads to new theory, some informs us as to trends, and some gives us leads in solving particular problems of disease occurrence. The competent sanitarian is interested in all of this. He should work with his health officer and members of the health department staff to collect, tabulate, and analyze data pertaining to health and disease in his area of jurisdiction. He should study such data from other places in order to better understand his own area.

How is data collected? Every health department has daily record forms for recording activities and findings. These should be executed in detail so that they will be understandable in the future, and so that the data in monthly, quarterly, annual, and special reports may be as correct as possible. Every health department has the legal function to collect vital statistics such as relate to births, deaths, and sickness. Special effort at such collection is exerted during times of stress and epidemic situations. For special purposes, sanitary or other health surveys are from time to time made that give special data. The sanitarian may find that other agencies, official, voluntary, or private may make surveys for special purposes relating to the community or of certain groups in the community which may contain data revealing conditions and circumstances pertaining to health. All such material should be of interest to the sanitarian. He should study, correlate, and build up a file of such source material in order to understand better the dynamics of social movement which reveal the factors tending to promote or retard health. The essential tool in doing this is the statistical method.

This chapter is not intended to be a comprehensive text for the study of statistics. There are many fine books which the sanitarian could use for such purpose. This is merely an attempt to impress the sanitarian with the importance of the statistical method so that he may see the rationale of seeking to further his knowledge in this field. It is an attempt to make the sanitarian cognizant of the fact that he may be expected, from time to time, to present data showing what he has accomplished by his routine activities, and by his special activities, and even to write and present a paper, as a professional health worker, in which the tabulation and analysis of collected data are necessary. To do such things requires knowledge of the statistical method. His data should have scientific value, otherwise it would have no value at all. Professional respect is gained by working, behaving, and contributing with scientific accuracy.

Statistics as a Tool of Epidemiology

The statistical method is an epidemiological tool. Every sanitarian who is conscious of his professional standing and seeks to work by its ideals must be an epidemiologist. He may or may not require the use of statistics in tracking down every case of disease, let us say of typhoid fever, food poisoning, or lead poisoning. He may accomplish this by sheer public health acumen, i. e., an acute sense of host-parasite and organism-environment relationships which he may have developed by disciplining himself in epidemiological procedure. The sanitarian learns to do this by routinely attempting to determine the dynamics involved in the causation of those diseases reported in his area of jurisdiction which usually occur as a result of a breach in sanitation. The

investigation of an epidemic, however, does require the use of statistical data. An investigation should be made in an organized manner in order to be effective and efficient. The simplest way of proceeding with such an investigation is to interview the household of each case and each pertinent contact while at the same time filling out an "epidemiological investigation sheet" in as great detail as possible. The collection of data on such a form gives uniformity to the information and makes possible its tabulation and analysis. An epidemiological investigation requires that:

1) The cases be identified and the diagnosis of each case be confirmed by the health officer.
2) All contacts be interrogated and studied.
3) The date of onset of the disease of each case be established.
4) The approximate date of infection of each case be established by use of the average period of incubation of the disease.
5) The place where the person probably acquired the disease be indicated.
6) The food or drink or any other agent carrying the disease be indicated as far as possible.
7) The necessary laboratory tests be made.
8) An inquiry be made as to how the food, drink, or other agent was contaminated or infected. What activity of the case had a bearing on his getting the disease, i.e., travel, visiting, working, entertaining, etc.
9) The data to be tabulated indicate the significant or insignificant part played by each suspected individual or agent.
10) All data be tabulated in order to be analyzed for significant indications as to the part played by age group, race, occupation, sex, area, economic class, and the like.

It must be understood that a lead given by significant statistical data is, in most instances, not conclusive evidence of the source of the spread. Most epidemics are not solved by the discovery of absolute evidence of the source and mode of spread. Usually, the solution is based on circumstantial evidence leading to the source of spread, and by eliminating, as far as possible, other sources and avenues of spread.

Epidemiological evidence includes:

1) Looking into the past history of the circumstances, for example, if water or milk be suspected: What has been the past sanitary history of the supply? Has the weather been especially hot or cold, or have there been recent storms? Have there been any cases of the disease in the area in the past? Have there been any mass gatherings of people in the recent past? etc.
2) Statistical data pointing in the direction of the source, and the elimination, as much as possible, of other statistical indications pointing to other sources. Incidence difference in age-groups, sexes, occupational groups, etc., may point toward peculiar circumstances of spread.
3) Laboratory tests on persons and materials involved.
4) The seasonal prevalence of the disease. For example, water-borne typhoid fever epidemics have a tendency to occur in the winter or spring of the year.
5) The explosive or non-explosive character of the outbreak. Both milk and water-borne epidemics have a tendency to occur in an explosive manner.
6) The area distribution of the cases may point toward certain area peculiarities responsible for spread, for example, distribution of cases in an area of a certain dairy route or public water supply or part thereof.
7) The discovery of a carrier or case located and working or moving about in such circumstances as to fit the picture of spread.
8) The discovery of particularly tell-tale insanitary circumstances such as a cross-connection or interconnections at an important location.

Epidemiological evidence may be based on other factors. The more the sanitarian knows about the mode of occurrence and spread of disease the more factors he will examine in fitting together the evidence for solving the causes of an epidemic.

The investigation of specific cases of disease occurrence is only one phase of the sanitarian's epidemological interests. He should also study the trends of mortality and morbidity from year to year in order to try to discover:

1) What affect certain public health practices and certain socio-economic developments have had on the population.
2) In what field of activity the sanitarian should emphasize his efforts from time to time so that the community be best protected.

3) What unsolved epidemiological problems may become elucidated.

The epidemiologist therefore must be continually collecting, tabulating and analyzing data. In order to be able to compare accurately certain things, events, and trends, it is necessary to give common denominators for the comparable data. For example, if a certain number of deaths or cases of disease occur in various classes of the population, these are reduced, for each class, to the rates of deaths or cases per 1,000, or per 10,000, or per 100,000 population. This gives us a better means of judging where and when the risk of dying or becoming sick is greater or less. The sanitarian should therefore know how to calculate data to show in what proportion certain events happen, so that he can more easily make comparisons.

The above sketchy outline of the sanitarian's activity in epidemological situations and in the study of epidemological data appears much simpler than the actual energy, alertness, ingenuity, persistence, genuine interest, and intellectual curiosity involved on the part of the sanitarian. The solving of an epidemiological problem requires much hard work, both foot work and brain work. In the gathering of information, the sanitarian must be persistent in questioning exhaustively all persons who appear in the slightest manner associated with the disease situation, and in investigating every clue in the environment that may seem to be significant in the fouling of the hygiene. The epidemiological record forms therefore must be filled out as completely as possible.

The Use of Collected Data

The tabulation of the collected data must be so done as to make possible the revelation of significant factors, such as: whether the disease occurred randomly in the population, or whether a particular age-group, race group, economic group, occupational group, or civic group, showed a preponderance of cases; whether a meteorological event, an accident in the operation of a sanitary facility, the travelling or migration or particular activity of people, or an assembling of people for social or other purposes, etc. was associated with the occurrence and spread of the disease; whether a particular food or drink or lack of these appear to show any significance. It is clear that the tabulation of collected data must be done with a purpose and with an understanding both of the problems involved in the spread of the particular disease and the technique of tabulation.

Rates. Bare quantitative tabulation is not enough. The quantities should be so related that events of disease occurrence may be proportionately compared. The quality of proportion allows the sanitarian to make exact comparisons of occurrence of significant events, and thereby brings the situation into sharper focus. For example, if,on tabulating data gathered during an epidemic of scarlet fever, the following results were obtained, a probable lead to the source of infection may be indicated by calculating the rates of occurrence:

Table 1 . Scarlet Fever Case Rate per 1,000 Population, by Source of Milk, for Time Period X, in the Town of Y.

	Persons	Cases	Case Rate per 1000 persons
Customers of dairy A	1,700	61	35.9
Customers of dairy B	2,300	12	5.2
Rest of population	47,000	174	3.8
Total	51,000	247	4.9

A rate describes the rapidity with which a given event occurs. For example, the case rate in the above table indicates how rapidly the cases of scarlet fever had occurred during the particular time of the epidemic in each 1000 persons who were and who were not customers of particular dairies. The result of the tabulation is significant indeed. It shows that the customers of dairy A developed scarlet fever seven times more rapidly than those who were customers of dairy B, nine times more rapidly than the rest of the population not served by either dairy, and seven times more rapidly than in the whole population. This precise evidence of how rapidly the disease was spreading in various groupings of the population was not very apparent without calculating the rates.

Another example is:

Table 2. Typhoid Fever Case Rates per 1000 Population, by District and Race, for Time Period X, in the Town of Z

	Cases			Population			Case Rates per 1000		
	White	Colored	Total	White	Colored	Total	White	Colored	Total
District A	18	6	24	1997	2762	4759	8.98	2.18	5.04
District B	52	2	54	5920	1000	6920	8.78	1.96	7.80
Total	70	8	78	7917	3762	11,679	8.86	2.12	6.68

If district A represented a section of Town Z which was economically on a higher level than district B where most of the colored population lived and was sparsely supplied with water from the central water system, then, an indication as to whether the central water supply may or may not be ruled out as a possible source of infection may be arrived at by the results of the calculated rates of occurrence.

A rate is defined as a relation which indicates the number of times a certain event occurs when a certain number of exposures to the risk of occurrence is present for a definite period of time.

It has been seen that a rate is a qualitative expression of quantitative data describing a dynamic process, i.e., the rapidity of movement with which a given event occurs. Another qualitative expression of quantitative data, which is very often confused with a rate is the "ratio." The ratio is described as a simple measure of relationship between two numerical quantities. These quantities need not represent the same entities, although the unit of measure must be the same for both numerator and denominator. For example, in Table 2, the number of typhoid cases in district A is 24, and the number in district B is 54; the ratio of cases in district A to those in district B is 1:2.25. Here the common unit of measure is the number of cases. The type of ratio commonly designated as a proportion is somewhat different. Here the entities in the numerator of the ratio must be included also in the denominator. Thus, the town population (Table 2) was 11,679 of which 7,917 were white; the proportion of the population which was white was, therefore:
$\frac{7,917 \text{ white}}{7,917 \text{ white} \quad 3,762 \text{ colored}} \times 100 = 67.8\%$. This proportion shows a relationship at a given instant of time, since at a different time the proportion might well be different. It is therefore a static comparison. If the time element enters a ratio, it must enter alike in both the numerator and denominator, i.e., the same time flow enters with both the numerator and denominator. A rate, by contrast is quite different. Here the numerator is a figure representing the collection of data over a period of time while the denominator represents a static figure, a count at a specific instant of time. But this gives the rate a dynamic quality as compared to the static quality of a ratio.

The formulae for calculating the more commonly used rates in vital statistics are given below, remembering that the population in which the events or the risk are assumed to be occuring is the population at the middle of the time period under consideration, and if the rate be an annual rate, the population would be estimated as of July 1 of the specific year.

Crude Birth Rate:

$$\frac{\text{Number of live births}}{\text{Estimated Population}} \times 1,000$$

Specific Birth Rate:

$$\frac{\text{Number of live births to women of a specific age}}{\text{Estimated female population of the same age}} \times 1,000$$

The Death Rate in a population is the number of deaths which occur in a day, a week, a month, a year, etc., in a definite population. Usually, this rate is expressed as the number of deaths per 1,000 or 100,000 population for a particular year. This rate attempts to measure the force of mortality on the general population, or to measure the rate at which a population is dying.

Crude Death Rate:

$$\frac{\text{Number of deaths}}{\text{Estimated Population}} \times 1,000$$

Specific death rates are distinguished from crude death rates in that the former deal with deaths from a specific cause, or in a certain age-group, race, social group, geographic group, etc.

Specific Death Rate by Cause:

$$\frac{\text{Deaths from the specific cause}}{\text{Estimated Population}} \times 100,000 \text{ (or } 1,000)$$

Age-Specific Mortality Rate:

$$\frac{\text{Number of deaths in a specific age-group}}{\text{Estimated population of that age-group}} \times 1,000 \text{ (or } 100,000)$$

Infant Mortality Rate:

$$\frac{\text{Number of deaths under 1 year of age}}{\text{Number of live births}} \times 1,000$$

Neonatal Mortality Rate:

$$\frac{\text{Number of deaths under 1 month of age}}{\text{Number of live births}} \times 1,000$$

Maternal Mortality Rate:

$$\frac{\text{Number of deaths from causes related to pregnancy}}{\text{Number of live births}} \times 1,000$$

Case Fatality Rate:

$$\frac{\text{Number of deaths from a specific disease}}{\text{Number of cases of the same disease}} \times 100$$

The commonly used morbidity rates are:

Incidence Rate:

$$\frac{\text{Number of new cases of a specific disease}}{\text{Estimated population}} \times 1,000$$

Prevalence Rate:

$$\frac{\text{Number of cases present at a given time}}{\text{Estimated population at that time}}$$

Attack Rate:

$$\frac{\text{Number of cases of a specific disease during a specific time}}{\text{Number of population exposed to that disease during that period}}$$

Proportional Mortality Ratio:

$$\frac{\text{Number of deaths from a specific cause}}{\text{Number of deaths from all causes}} \times 100$$

Calculation of Population for Intracensal Years

Because the census is taken only once every 10 years, it becomes necessary to determine the expected population for any of the intervening years if we wish to keep our statistical calculations more or less correct for these intervening years. This is accomplished by a method which gives a mathematical approximation of any year's population. For example: If the population of a certain community were 5000 in 1930, and 7000 in 1940, and we wished to determine its approximate population for the intracensal year 1935 and the postcensal year 1945, we assume that the growth of the population between 1930, 1940, and 1945 be even and gradual. The date of the census is on April 1. The mid-year population is calculated as of July 1.

Given			Find
Pop.	Year	Census date	Intracensal estimated population for July 1, 1935 (mid-year population)?
5000	1930	April 1	5000 + (63 months x 16.67 or 5 1/4 years x 200) = 6050 population.
7000	1940	April 1	
Increase between 1930 and 1940 = 2000			Postcensal estimated population for July 1, 1945?
Annual increase therefore = 200			7000 + (5 1/4 years x 200) = 8050 pop.
Monthly increase therefore = 16.67			

Other Statistical Tools

The foregoing simple mathematical techniques are the elementary tools of vital statistics. There are, however, a number of more complicated mathematical tools which should be known if one wishes to gain greater proficiency in analyzing vital data. Some of these techniques will be mentioned only to indicate to the sanitarian how broad the field of vital statistics really is, but it is not the purpose of this chapter to be a text on vital statistics.

In order to compare groups of similar data in a very simple manner, three commonly used measurements are available —the mean, the median, and the mode.

In order to describe adequately the manner in which certain variable events are distributed (i.e., the frequency distribution), four commonly used methods are available —the range, the interquartile range, the average deviation, and the standard deviation.

In order to determine whether certain characteristics of a sample will adequately describe the characteristics in the whole group, i.e., whether the mean of the sample accurately represents the mean of the whole, the standard deviation of the mean (or the standard error) of the sample is used.

In order to determine whether, in comparing two samples, they represent fundamentally the same or different wholes (or universes), i.e., whether there be any significant difference between the two samples, the difference in means is used.

In order to measure the longevity or expectation of life by age-group, the life table is used.

In order to determine the probability with which an event (ex. a rate or ratio) can happen in more than one way, the point binomial method of calculating this is used.

In order to determine whether difference in distribution between events in two samples (ex. rates or ratios) is likely or not likely to have occurred by chance, the method called significance of difference in proportions or the Chi-Square test of association can be used.

In order to make possible an estimation of the minimum size of a sample to give any desired degree of certainty that it represents adequately the universe, a method of calculating this has been developed.

In order to be able to measure the degree of relationship or association between two quantitatively expressed variables, the correlation method may be used.

In order to determine whether the analysis of measurement data resulting from small samples be significant the "t" test for small samples method is used.

The Interpretation of Statistical Data

Statistics can be accurate and also very inaccurate and thus unreliable. It all depends upon who collects, tabulates and analyzes the data, and who interprets the results. One often hears cynical references to statistics in the sense that "one can make figures tell any story one desires." There is a certain amount of truth in this dictum but it is only a half truth, and a half truth is dangerous when accepted as a relatively whole truth. Statistics accurately interpreted do not give false evidence. But in order to give truthful evidence statistics must be truthfully and adequately gathered and tabulated. For example, we were exceedingly pleased to note that during the depression years, our infant mortality and our general population mortality steadily declined. Thus, some who wished to point out that this was conclusive proof that we needed no better health service for our people than already existed, and that the family incomes of depression years were adequate to allow our people to grow continually healthier were pleased to quote these figures. But on more accurate analysis of the data a different picture was revealed. The actual situation was that although only 30 infants died out of every 1,000 born alive into families with annual incomes of $3,000 or more, 168 died out of every 1,000 born alive into families with annual incomes of $500 or less, that is, among the low income group, babies died at a rate of more than five times as much as in the higher income group. And, whereas the general death rate declined in families whose members were fully employed in 1929-32, it rose 20% among those families whose

members were either part time employed, or not employed at all. This shows that general averages only apply for homogeneous groups, but not for groups that are separated by unreconciliable conditions. Correct analysis and interpretation is, therefore of utmost importance in the use of statistics.

The understanding of the difference between the individual and the group as social entities must also be understood in order not to fall into fallacies. Statistics is the mathematics of group events and therefore the dynamics of groups must be correctly conceived in order to correctly interpret data. In no instance is it valid to compare individual events with group occurrences, since the average is always different from the individual entities composing the average, and what occurs in a group has a different quality than that which occurs to an individual, i.e., what occurs in a group is usually measured by average occurrence. Thus, every average is composed of variables between two extremes, and individual happenings may be quite different from the average.

Collection of Birth, Death, and Morbidity Data.

There are several government agencies that collect and publish statistical data which are basic materials of public health statistics. The census Bureau furnished population statistics. The U.S. Public Health Service furnishes periodic morbidity reports and its National Office of Vital Statistics furnishes statistics on births, deaths, marriages, divorces and similar data. The census of the United States is taken every tenth year, and has been taken at such intervals ever since 1790. In order to unify the statistics of births and deaths in our country, the Federal Government created the "United States Registration Area" in 1880, to which those states are admitted whose collections of births and deaths are adequate, i.e., where such statistics are collected for at least 90% of the population. In 1880, only two states, namely: Massachusetts and New Jersey were admitted. At present all states are in the "Registration Area."

The Bureaus or Divisions of Vital Statistics of states are usually under the Departments of Health. The method of collecting vital statistics data begins in the small political units of the states such as incorporated towns, cities, and counties. The data collected is sent to the State Vital Statistics unit, and from there to the National Office of Vital Statistics.

There are three important types of reports which are executed locally, mostly by physicians, and some by midwives, which are the backbone of the entire nation's vital statistics. They are:

1) Birth Certificates —filled out by physician or midwife.
2) Death Certificates — " " " " " "
3) Reportable Disease Reports —filled out by physicians

These corner stones, plus the Federal Government's Census gathering, and the marriage and divorce records form the foundation of our whole system of Vital Statistics. There are, besides these, other supplementary sources of vital statistical material, such as life insurance company records, and surveys of various kinds.

The birth and death certificates are usually collected by local registrars appointed by the State government. Usually the laws require that such certificates, for any month, must be executed and transmitted so that they reach the local registrar within a short period (usually no longer than 10 days) after the termination of that month. The law usually requires that the attending physician immediately fill out a reportable disease card upon diagnosing any reportable disease, and that he send it to the local or state health department so that the public health procedures necessary in each case be immediately carried out by the health department.

Tabulation of Statistical Data.

The raw material of statistics consists of individual observations of events as they occur in relation to certain conditions. For example, we not only record the death of a child, but also record its death by referring to its age, location, cause of death, etc. After collecting such records we could tabulate the information in the form of lists or tables so as to retain the identity of each individual event. Material assembled in such a manner is usually too cumbersome for practical usage; instead therefore, observations are so arranged in tables that all similar events are placed together, thus losing the identity of individual events but gaining by bringing to light the collective force of all similar events. The purpose of tabulating data, then, is in order to arrange observations so that all similar events shall be placed together and their frequency of occurrence within

the whole group of observations brought to light. Tabulation may be defined as the process of arranging in tabular form observations which are related in order to bring into view an organized picture of the interrelationships inherent in the mass of these observations. These relationships tell us what is happening in the population —in what group of the population, in what environment, in what season, in what geographic area. They reveal where serious problems exist, or are developing, and may even aid us in solving those problems.

A statistical table consists of a heading, subheadings and columns of itemized data. A list of unrelated events does not constitute a table. A table should be as simple in construction as possible without interfering with its purpose. The table heading, subheadings, and column headings should describe briefly and clearly their contents. The title is almost always placed at the top of the table. Subheadings or column headings should be placed immediately above the columns to which they pertain. The arrangements of the data in any given instance is determined largely by the purpose of the table and the character of the observations which are to be tabulated. For example, let us consider the following table:

Table 3. Water Supply and Sewerage Needs in the United States.* 1946

Character of Needs	Urban		Rural
	No. Persons	No. Communities	No. Persons
Have no waterworks	2,360,000	5,710	27,200,000
Need improvement of waterworks	79,072,000	15,000	
Have no sewerage systems	6,360,000	9,100	33,200,000
Need improvement of sewerage systems	79,349,000	9,900	
Reporting no needs in water supplies	10,720,000		12,300,000
Reporting no needs in excreta disposal	6,443,000		6,300,000

*Nation-wide Inventory of Sanitation Needs. Public Health Reports, Supplement No. 204, April, 1948.

From the above, it becomes clear how the efforts of thousands of people who collect data can be neatly organized into a meaningful simple table of a few lines and a few columns which gives a birds-eye view of the needs in the sanitation of water supplies and excreta disposal for the whole of the United States. Such information is invaluable in a nation-wide planning program.

Graphic Presentation of Statistical Data

A graph is a method of showing quantitative data. Graphic methods may be employed in statistical work either for the purpose of facilitating statistical studies, or as a means of presenting statistical data so the eye can quickly convey to the mind a more or less unified picture of the significance of the mass of figures. Graphic presentation is accomplished principally by the use of diagrams to compare observations, to represent the frequency of occurrence or distribution of certain events, or to depict the trend of a series of events.

The statistical diagrams commonly used in epidemiological work include the line diagram, bar diagram, histogram, pie diagram, and maps.

The usual simple statistical diagrams are represented by points connected by lines. Each point is in a definite position which can be measured by its distance from two lines at right angles to each other. For example, in Fig. 1, the position of point "p" can always be located by measuring its horizontal distance from line "oy", and its vertical distance from line "ox." These two lines, "oy" and "ox," are called a system of "rectangular coordinates" because the lines in the system form 90 degree angles.

Statistical data have two basic characteristics:
1) The class of events to which they belong.
2) The frequency of occurrence of these events.

The horizontal distance will represent the classification of events arranged in series, such as events occurring in January, February, March, April, etc., or diseases occurring in 1900, 1905, 1910, 1915, etc. The vertical distance will represent the frequency or magnitude of each class of events, such as 186 deaths per 100,000 population in 1900, 149 deaths per 100,000 in 1905, etc.

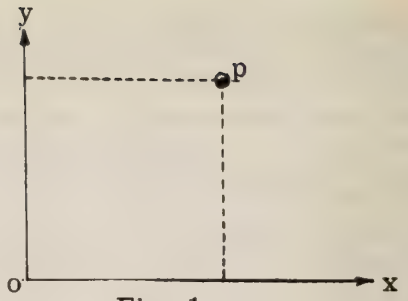
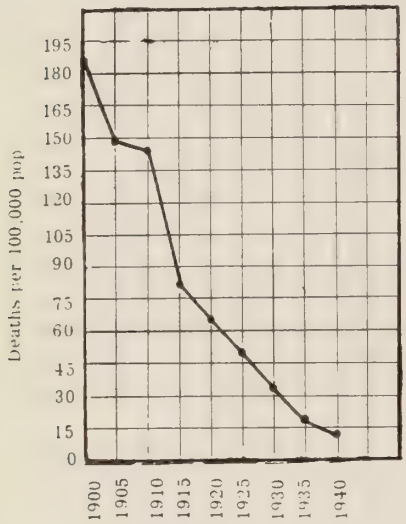
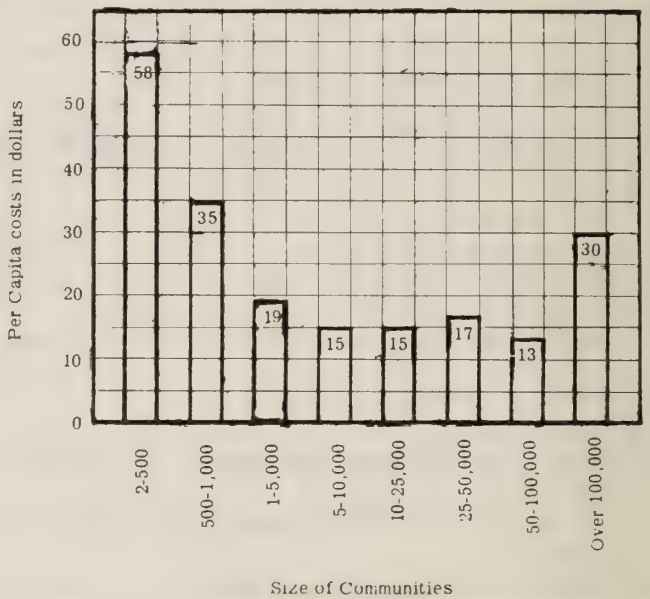


Fig. 1

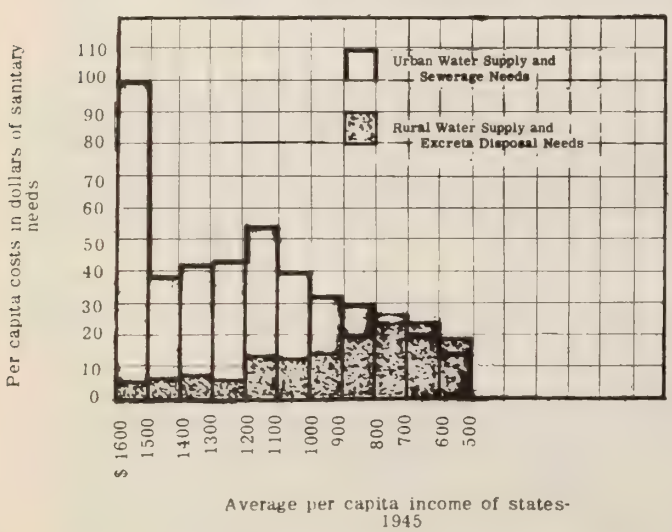


Graph 1. Trend of Death Rates per 100,000 population from Enteric Diseases, United States, 1900-1940.



Graph 2. Water Supply Sanitation Needs in Terms of Per Capita Cost for Communities of Various Size in United States - 1946.

The Line Diagram, then, is usually employed to show the frequency of occurrence of a series of related events, and to depict the magnitude of variation and the trend of events in time. This is illustrated by putting Table 4 into line diagram as shown in Graph 1.



Graph 3. Water Supplies and Sewerage Needs by Income Level of States - Urban and Rural-1946

Bar Diagram. This form of diagram can be used most satisfactorily to compare qualitative or quantitative data of discrete type, such as number of males and females, population by color, or income of groups, and urban and rural distribution. The bars may be drawn either horizontally or vertically. Regardless of the direction of the bars, a scale of measurement should be shown and the scale must start at zero. For example, let us change Table 5 into a bar diagram (See Graph 2).

Histogram. This form of diagram is used exclusively for showing distributions of quantitative data which are continuous in nature. Let us put Table 6 into a histogram form of graph (See Graph 3.)

Table 4. Trend of Death Rates per 100,000 Population for Enteric Diseases in the United States from 1900 to 1940

Diseases	1900	1905	1910	1915	1920	1925	1930	1935	1940
Diarrhea, enteritis and intestinal ulcers	142.7	118.4	115.4	67.5	53.7	38.6	26.0	14.1	10.3
Typhoid and paratyphoid fever	31.3	22.4	22.5	11.8	7.6	7.8	4.8	2.8	1.1
Dysentery	12.0	8.3	6.0	3.4	4.0	3.1	2.8	1.9	1.9
Totals	186.0	149.1	143.9	82.7	65.3	49.5	33.6	18.8	13.3

Table 5. Water Supply Sanitation Needs in Terms of Per Capita Cost for Communities of Various Sizes in United States - 1946

Community Population	200-500	500-1,000	1,000-5,000	5,000-10,000	10,000-25,000	25,000-50,000	50,000-100,000	Over 100,000
Per Capita Costs	$58	$35	$19	$15	$15	$17	$13	$30

Table 6. Water Supply and Sewerage Needs by Income Levels of States - Urban and Rural. 1946

		Average Per Capita Income of States - 1945										
		1,500-1,600	1,400-1,500	1,300-1,400	1,200-1,300	1,100-1,200	1,000-1,100	900-1,000	800-900	700-800	600-700	500-600
Per Capita Costs in dollars of sanitary needs	Urban	100	38	42	44	53	40	32	30	25	21	15
	Rural	4	5	7	5	13	12	15	21	23	23	19

The Pie Diagram is used in showing percentages into which a whole has been subdivided. It is an area diagram of circular shape broken into subdivisions that are based on a construction so that each percent is equal to 3.6 degrees of the circle. The subdivisions should be few so that the detail may be readily grasped.

The Proportional Bar Diagram is used in comparing two or more proportional distributions of either qualitative or quantitative data in which the number of groups is relatively small. The histogram, Graph 3, also illustrates the proportional bar diagram where the bars are proportionally divided to compare the urban and rural needs.

A very simple and effective use of collected data to indicate the areal distribution of events is the spot map. Such maps indicate graphically the locality of occurrences of events by properly locating each event by a dot or pin on the map. This type of map is much used in epidemiological work. When a number of cases of disease occur in an area, it is easier to get a mental picture of the distribution of the cases on a spot map than by trying to accurately conceive a mental picture of the distribution without such a map.

The sanitarian should refer to a book on statistics if he wishes to acquaint himself with the other less simple forms of graphical expression.

All the methods of presenting statistics graphically have certainly not been exhausted in the above presentation. There are other forms of graphs called frequency polygon, ogive curve, integral curve, line diagram on arithlog grid, pictogram, scatter diagram, shaded map, and new forms are continually coming into use. Those presented here are the simple basic forms which the beginner must first learn to use.

In 1915 a widely representative joint committee of engineering, statistical, economic, biologic, and other societies, interested in the promotion of sound methods of graphic presentation of data, published a report on standards. Some of these standards referring to simple procedure are outlined below.

1) The general arrangement of a diagram should proceed from left to right and from bottom to top.

2) Whenever possible, represent quantities by lines or bars, since these are more easily and correctly interpreted at a glance, than if the quantities were represented by areas or volumes.

3) In the line diagram, the vertical scale, whenever practicable, should be selected so that the zero line will appear on the diagram.

4) If the zero line of the vertical scale will not normally appear on the line diagram, the zero line should be drawn by the use of a horizontal break in the diagram.

5) The zero lines of the scales for line diagrams should be sharply distinguished from the other coordinate lines.

6) For line diagrams having a scale representing percentage, it is desirable to emphasize in some distinctive way the 100 percent line or other line used as a basis of comparison.

7) It is advisable not to show any more coordinate lines than necessary to guide the eye in reading the diagram.

8) The curve line in a line diagram should be sharply distinguished from the ruling lines.

9) In curves representing a series of observations, it is advisable, whenever possible, to indicate clearly on the diagram all points representing the separate observations.

10) Figures for the scales of a diagram should be placed at the left and at the bottom.

11) It is often desirable to include in a diagram the exact numerical data which the lines or bars represent.

12) If numerical data be not included in the diagram, it is desirable to give the data in tabular form accompanying the diagram.

13) All lettering and all figures on a diagram should be so placed that they may be easily read when either the bottom or the right hand side of the diagram is used as the base.

14) The title of the diagram should be made of clear, complete, and concise as possible. Subtitles or descriptions should be added if necessary to insure clearness.

Chapter XXXIV

Nuisances; Bedding, Mattress, and Upholstery; Barber Shops and Beauty Parlors; Turkish Baths and Massage Parlors

Nuisances, bedding, mattresses, upholstery, barber shops, beauty parlors, turkish baths and massage parlors are not a closely related group of items from a public health point of view. They have in common, however, the virtues of not being fundamental health problems, of not needing separate theoretical discussion, but of requiring separate administrative regulations for control. They are a group of miscellaneous items which need a certain amount of public health attention by the sanitarian because they may be the sources of disease spread, the causes of mechanical and chemical injury to the public or merely creators of nuisances which may disturb the emotional and mental equilibrium of those affected. Whatever theory is necessary to understand the problems involved may be gleaned by the sanitarian from the discussions elaborated concerning the various basic aspects of public health presented hereinbefore.

Nuisances may be or may become factors in the spread of disease, in the causation of accidents, or in the disturbance of the psychic tranquillity of people. Some nuisances are obviously not in the traditional realm of public health. But who can designate precisely what belongs to public health authorities and what belongs in the jurisdiction of other public agencies when considering the problem of nuisances? They are nevertheless our concern, and, as the stress of life becomes greater, nuisances also become our greater concern, since psychic composure is such a desirable state in our population under the pressures of the present day.

No one can doubt that bedding, mattresses and upholstery may, in the realm of possibility, cause the spread of disease, but we need not place these possibilities in an important position. Mainly, the control of such items relates to the esthetic and the economic, and to the spread of bugs and insects.

Barber shops, beauty parlors, turkish baths, and massage parlors are more important in the spread of disease and should definitely be the concern of the health authorities. The following regulations give a good summary of the administration of control. These regulations were excerpted from those drafted by the Engineering Section Project of the American Public Association, and in some instances have been modified.

Nuisances

Authority of the Board of Health

Whenever any declared nuisance, source of filth, or cause or probable cause of injury to health shall be found by the health officer to exist on any private or public property within the area of his jurisdiction, he shall have the power and authority to order in writing the owner or occupant or user thereof, by appropriate action, at the expense of such owner, occupant, or user, to correct and remove said nuisance, source of filth or cause or probable cause of injury to health, within 24 hours or within such reasonable time as the health officer may order.

Public Nuisances Affecting Health

The following are hereby declared to be nuisances affecting health as well as and in addition to any other act, omission of act, occupation and/or use of property premises, equipment or structure deemed to be a menace to the health of inhabitants so declared in any other section of the sanitary code:

All decayed or unwholesome food offered for sale to the public.

All diseased animals running at large.

All ponds or pools of stagnant water.

Milk which is produced by cows which have not been tested and found free of tuberculosis within the year previous to the offering of such milk for sale to the public.

Carcasses of animals not buried or destroyed within 24 hours after death.

Accumulations of manure or rubbish not conforming with provisions of the sanitary code.

Any human excreta disposed of in any other manner than provided under the sanitary regulations, and any repositories of human excreta existing or maintained contrary to these regulations.

Garbage cans which are not fly tight.

The pollution of any well, cistern, spring, underground water stream, lake canal, or body of

water by sewage or industrial wastes, or other substances harmful to human beings.

All noxious weeds and other rank growths upon public or private property.

Dense smoke, noxious fumes, vapor gas, dust, and soot, or cinders, in unreasonable or toxic quantities.

Offensive trades and any other businesses not having permits issued by the board of health as provided by the sanitary code.

All public exposure of persons having a contagious disease.

The use of a common public drinking cup or roller towel.

The distribution of samples of medicines or drugs unless such samples are placed in the hands of an adult person.

The use, or sale, or distribution of any toxic substance in such a manner and for such purpose as the health officer may declare to constitute a hazard to the public.

Any vehicle used for any purpose requiring a permit issued by the health officer or the board of health and operated for such use without such permit.

Any building or structure in which people are housed or congregate for any purpose which in the opinion of the health officer have become dangerous for further occupancy because of structural, sanitary, or other defects.

All buildings, walls, and other structures which have been damaged by fire, decay or otherwise to an extent exceeding 1/2 their original value, and which are so situated as to endanger the safety of the public.

All explosives, inflammable liquids and other dangerous substances stored in any manner or in any amount other than that provided by ordinance or by the sanitary code.

All unnecessary noises and annoying vibrations.

All buildings and all alterations to buildings made or erected in violation of the provisions of the sanitary code.

Any insanitary use of property abutting on a public street or sidewalk or any use of public street, alley, sidewalk, public way or public place which causes obstruction of traffic and property or the free use of the streets or sidewalks.

All dangerous or insanitary, unguarded, unprotected machinery or equipment in any public place, or situated or operated on private property in violation of provisions of the sanitary code.

All infestations of flies, fleas, roaches, lice, ticks, rats, mice, fly maggots, mosquito larvae and hookworm larvae.

The declaration of the above nuisances shall not be construed to limit the power of the board of health to review any specific condition believed to be a nuisance by the health officer, and after each review to declare such condition a nuisance whenever the facts presented by the health officer are conclusive that a nuisance has been or is being committed.

Regulations for Special Types of Nuisances

Stockyards. No person, firm or corporation shall erect, install, construct, operate or maintain a stockyard in the area of jurisdiction otherwise than as provided herein or permit the same to be done on any premises owned, occupied or controlled by him.

The term "stockyards" as used in this chapter shall be construed to mean any place where livestock is confined temporarily awaiting transportation and shall not include barns, stables, hogpens, or other places where livestock is kept permanently.

Every stockyard shall be constructed, operated and maintained in accordance with the following standards and requirements:

a. A watertight floor shall be provided and adequate drainage supplied.

b. The yard shall be kept reasonably clean and free from manure and other refuse. When in use, the yard shall be cleaned daily and the refuse disposed of as provided in this code.

c. No stockyard may hereafter be constructed at a point nearer than 300 feet to any place of human habitation except upon written permission of the affected property owners and of the board of health.

d. Animals may be kept in the yard before shipment not longer than 48 hours between March 31 and November 15, and not longer than 72 hours between November 15 and March 31.

e. Every corporation, firm, or individual whose business and function is to receive, buy, sell, handle, deal or trade in livestock while contained in the pens of any public stockyards or pens shall have before said stock an adequate supply of fresh water at all times between the hours of 10 a. m. and 12 noon of each and every day, and all stock that may arrive or are in any of the

said yards or pens after 12 noon shall be watered before 6 p. m. Cattle carried over from day to day by anyone shall be watered and fed each day while confined in any pens.

f. Whenever in the judgment of the health officer a stockyard or the conduct thereof is a menace to public health or is a nuisance he shall notify the person, firm or corporation owning or operating such stockyard, requiring him to remove such condition or remedy such defect within a time not exceeding 30 days, to be specified in the order. If at the expiration of such time such order has not been complied with, the board may prohibit the further use of the yard.

g. Whenever the use of any railroad stockyard has been prohibited by the board of health, the health officer shall so notify the appropriate regulating authority and shall request that adequate and suitable facilities be provided for the loading of stock, unless facilities be otherwise provided.

h. Every person, firm or corporation who shall directly or by its agent violate any of the above provisions, or who shall continue to operate any stockyard after its condemnation by the local board of health, shall be deemed guilty of a misdemeanor.

Keeping of Animals or Fowl in Other Than Stockyards. Any person who keeps or desires to keep or intends to engage in the business of keeping any animals or domestic fowl or tame birds or reptiles within the incorporated limits of any municipality or within the limits of any recognized community shall register that fact with the health department, and also give information as to the number and kind of animals, birds, fowl or reptiles to be so kept with the health department unless specifically exempted under these regulations, and shall be held responsible by the health officer, whether exempted or not, for the maintenance of all such premises in a clean and sanitary condition in conformance with all applicable provisions of the sanitary code.

Exceptions to registration required above shall be made whenever:

a. The animal kept or to be kept as a pet, dog, cat, rabbit, or similar animal commonly called a pet, owned by a person residing on the premises, does not exceed a total of two over four months old, and is not an animal or fowl, or a reptile prohibited under this or any other section of the sanitary code.

b. The animals or fowl are kept or to be kept on premises 1 acre or more in area and intended to be used only for private use and not for any business, sale or hire.

c. The animals, fowl, birds or reptiles are kept in a zoological garden or similar exhibition place under ownership and supervision of a public agency.

d. Animals or fowl are kept in approved laboratories for experimental purposes.

e. Animals or fowl are kept or maintained on a farm.

In addition to permits otherwise required under the sanitary code and except for the exemptions named above, a specific permit shall be obtained from the health officer for the keeping of animals or fowl within any municipality or recognized community as follows:

a. The keeping of one or more swine, sheep, goats, horses, asses, donkeys, mules, ponies, cows or animals raised for fur-bearing purposes.

b. The keeping of more than 20 chickens or pigeons over 4 months old.

c. The temporary keeping of domestic animals for the purpose of shoeing.

d. The shelter of large domestic animals temporarily or permanently in such places as stables, stalls, barns or paddocks.

e. The keeping of more than six dogs or cats over 6 months old.

f. The keeping of more than two rabbits or guinea pigs more than 4 months old.

g. The keeping of more than two ducks, geese or turkeys over 4 months old.

No person may keep any animal, fowl or reptile in or on any premises where such keeping is prohibited by law or ordinance of any municipality; or is prohibited as a use of property by the zoning commission; or is prohibited by a regulation of the building inspector, fire prevention bureau or any other governmental authority having competent jurisdiction.

The following are specific prohibitions within the area of jurisdiction:

a. No person other than a zoological garden owner may keep a poisonous reptile of any kind or a wild animal with vicious propensities on any premises.

b. No person may be issued a permit to keep any animal or fowl, the keeping of which requires a special permit unless:

1. The animal or fowl were being kept on such premises in compliance with the sanitary code and without nuisance prior to the passage of this section.

2. The animal or fowl can be kept on premises in compliance with all applicable provisions of the sanitary code in an area where not more than three dwelling units or rooming units or a combination of either totaling three were within 100 feet of the structure, housing such animal or fowl at the time the permit was applied for.

c. No person requiring a permit to keep animals whose premises now are or subsequent to the adoption of these regulations become a part of a municipality by annexation, may reapply for such permit applicable to such premises after any permit held under the provisions of a. or b. above has been revoked by the health officer, and:

1. No animal or fowl on or in such premises may be restocked from sources outside the premises unless authorized to do so by the health officer.

2. Whenever premises come within a restricted area wherein the keeping of such animals or fowl is prohibited by reason of zoning, fire, or other such ordinance as specified above, or whenever such premises become a nuisance for reasons beyond the permit holder's control, the health officer shall give notice of intention to revoke the permit for keeping animals or fowl applicable to such premises and shall specify a time limit not exceeding six months from date of issuance of the notice for disposal or removal of all prohibited animals or fowl from such premises, and the permit shall be automatically revoked at the close of business on the last day specified for the expiration of the time limit.

3. Whenever a chicken coop, dove cote, dog kennel, rabbit warren, or other yard or establishment where small animals or fowl are kept shall be maintained closer than 40 feet to any tenement or apartment house, hotel, restaurant, boarding house, retail food stores, building used for school, religious or hospital purposes, or residence other than that occupied by the owner or occupant of the premises upon which said creatures are kept, the permit shall be revoked.

Every stable or other building wherein any animal such as swine, sheep, goats, horses, asses, donkeys, mules, ponies, cows or animals raised for fur-bearing purposes is kept shall be constructed of such material and in such manner that it can be kept clean and sanitary at all times.

a. Every such stable or other building occupied by authority of a special permit shall be provided with a watertight and fly tight receptacle for manure, of such dimension as to contain all accumulations of manure, which receptacle shall be emptied sufficiently often and in such manner as to prevent its becoming a nuisance. Said receptacle shall be kept securely covered at all times except when open during the deposit or removal of manure or refuse. No manure shall be allowed to accumulate except in such receptacle.

b. The health officer shall require such measures as are necessary to avoid a nuisance, and shall require that any such building be screened tightly against flies, and that it be provided with running water, sewer drain connection, flooring impervious to water, and that such other measures be taken as may be necessary to insure proper protection to public health and safety and compliance with the sanitary code as conditions precedent to the issuance of any such special permit.

All structures, pens, coops, or yards wherein small animals or fowl are kept or permitted to be kept, shall be maintained in a clean and sanitary condition, devoid of all rodents and vermin, and free from objectionable odors.

a. The interior walls, ceilings, floors, partitions, and appurtenances of all such structures shall be whitewashed or painted annually or oftener as the health officer shall direct.

b. The health officer, upon the complaint of any individual or person, shall inspect any such structure or premises and issue any such order as may be necessary to carry out the provisions of this code.

No person shall suffer or permit any horses, mules, donkeys, ponies, cattle, sheep, goats, swine, rabbits, chickens, geese, ducks or turkeys of which he is the owner, caretaker or custodian to be at large within a municipality. Any such creature shall be deemed to be at large when it shall be off the premises owned or rented by its owner and unaccompanied by the owner or an agent or employee of the owner, the caretaker, or the authorized custodian.

No manure shall be dumped or left unsupervised on any street, alley, sidewalk, or on any open area or lot in any inhabited portion of any municipality. Neither shall any manure be used to grade in whole or in part any sidewalk, street or public area in such municipalities unless said manure be completely covered with at least 4 inches of dirt.

No waste vegetable matter or animal matter, used for the feeding of swine, sheep, goats, cows chickens, geese, or ducks, shall be cooked within the city limits.

Noxious Weed Control. Whenever any person, firm, corporation, public agency, or institution shall request the health department to advise on the control of noxious weeds and plants including ragweed, poison ivy or any other species of weed or plant or growth, or the seed, pollen or other emanation thereof, which when carried through the air or otherwise dispersed, is noxious or detrimental to health or a nuisance, the health department shall give such advice and assistance within its means and facilities.

No person may use any dangerous or toxic chemical for the purpose of noxious weed control on premises other than his own without the advice and approval of the health department.

No person may use chemicals in spray or mist form harmful to persons or to property not owned by him except in concentrations equal to or less than those approved by the Health Department.

The health officer shall be guided by the current recommendations of the U. S. Public Health Service, and/or the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, for useful concentrations, suitable chemicals, satisfactory methods and safeguards, and protective measures to be instituted whenever such chemicals are used.

Procedures in Handling Nuisances

The health officer, upon receiving a complaint of the existence within his jurisdiction of a nuisance which may affect health, or is or may be so offensive to the senses as to interfere with the comfort or enjoyment of life, or when the probable existence of any such nuisance exists shall take all measures within his power and authority to secure its abatement.

At the discretion of the health officer, he or his representative may inform the complainant that an investigation will be made if the complainant be willing to testify concerning the nuisance in case such testimony may be required; otherwise the complaint will not be accepted for investigation.

Any complaint received from an authoritative source by the health department shall be recorded on special forms.

a. An authoritative source shall be any person or the representative of any firm, corporation, public agency, institution, or other group whose identity is known to the health department, and who complies with the requirements for reporting complaints.

b. Information received from sources other than authoritative shall be considered as casual information and the health officer may use his discretion in investigating any conditions so reported.

Complaints clearly not the responsibility of the health department, either wholly or jointly with another agency, shall be referred to the agency having jurisdiction.

a. In the same manner in which the complaint or information was received, the complainent shall be notified of the proper agency, if known, to which the complaint should be referred when the health department has no jurisdiction.

b. Joint responsibility complaints shall be investigated by the health department if it has the better facilities for so doing, or shall be referred by the health department together with all information relevant to the complaint to the agency having competent jurisdiction and better facilities for handling the investigation.

1. In the former event, a report of findings shall be rendered to the agency having a joint responsibility.

2. In the latter event, the health department shall assist the agency having joint responsibility to the extent of the health department facilities, whenever requested to do so by that agency.

Any complaint accepted for investigation by the health department shall be processed diligently in the following manner:

a. A sufficient investigation shall be made to determine all relevant facts.

b. A report shall be made on the special forms or on the sheets attached thereto, or in special cases in complete narrative brief, which shall contain the findings, and a statement that the complaint is a justified complaint in which the health officer has sole or joint responsibility, or has no responsibility and in that event the agency name to which the complaint is referred.

c. The necessary actions indicated by the findings shall be taken by the health officer or his agents to eliminate the cause of nuisance, if such exists, by all processes of education, persuasion, explanation, and legal action when necessary to secure abatement.

d. Whenever a complaint is investigated on any premises, the investigator shall note in addition to the findings on the condition investigated:

1. Any act, omission, or condition on such premises which is not in conformance with provisions of the sanitary code.

2. Any act, omission, or condition on adjoining premises which is not in conformance with the sanitary code.

e. Whenever a condition found upon such complaint investigation is found not to comply with any provision of the sanitary code, all appropriate measures to bring the condition into compliance shall be taken according to applicable provisions of the code.

1. Whenever the health officer, or the board of health, deems that legal action is required to abate a nuisance, the health officer shall require an officer of the law having jurisdiction to serve all notices, warrants or summonses.

2. Whenever required hearings are held by the health officer or his agents, notice of such hearings may be transmitted by whatever means is deemed by the health officer to be satisfactory in the particular circumstances.

f. The following items of information, among others, shall be recorded on special complaint report forms:

1. Complaint number.

2. Address of complaint or exact location by a uniform location system, if there be no street address.

3. Date complaint filed.

4. Name of person receiving complaint.

5. Name of investigator of complaint.

6. Name, address, and telephone number of owner, agent or other person responsible to the health officer for any premises, building structure, or equipment included by complaint or investigation.

7. Name, address and telephone number of complainant.

8. Specific details of complaint.

9. Specific conditions found on premises in initial investigation and the date of such investigation.

10. Whether complaint be justified or not.

11. Order issued, if any, and the date and time issued.

12. Name of agency to which complaint was referred as a joint responsisility.

13. The conditions or results noted on any subsequent investigation and the date of such entry and/or investigation.

14. The results of any conferences, information meetings, or agreements reached and the dates and names pertinent to such conferences.

15. Any formal actions of the board of health which may occur and the dates thereof.

16. Any court actions, or notices, or warrants requested to be served, and the dates thereof and by whom served.

17. Final disposition of complaint by abatement, referral or otherwise together with the date and signature of the investigator or person taking the final action.

A copy of the complaint record shall be available on request to any agency having joint responsibility with the health department.

a. A notice containing items 1, 2, 3, 6, 8 and 17 of above shall be reported to each such agency upon final disposition of the complaint.

b. The health officer shall request each agency having joint jurisdiction over a complaint condition to report information obtained by such agency equivalent to that furnished to the health department.

The health department shall maintain a premises file by address, and each complaint or any pertinent or relevant information from time to time accumulated by specific studies, investigations, inspections or visits of such premises shall be maintained therein in any form suitable to

the records system of the health department.

Any notice required to be served on a person, owner, agent or occupant of a premise, or a permit holder, shall be deemed to have been served when:

a. Such notice is delivered to such person by hand of any authorized agent of the health officer or any officer of the law.

b. Such notice is mailed by registered mail to the owner, or representative of the owner, or permit holder on record in the health department, or the last known occupant of the premises.

c. Such notice, properly signed, is posted by the person issuing the notice upon any portion of such premises visible from a public place, whenever the owner, or agent of the property is unknown.

d. A general notice addressed to multiple ownership, as may occur in the statement of noxious weeds or plants, is published with data defining the area or areas affected by such notice in a newspaper of general circulation on three successive days of publication, and in the official legal publication of the jurisdiction in which such area or areas may be situated.

Bedding, Mattress, and Upholstery Sterilization

Definition

The following terms apply specifically for the processes and materials governed under this heading and shall apply whenever the process of sterilization of such materials is governed under a provision of the sanitary code, unless the context clearly indicates another meaning or unless elsewhere expressly stated for specific application.

Bedding or article of bedding shall be considered to include upholstered furniture and filling material and any mattress, pillow, cushion, quilt, bed pad, comforter, upholstered spring bed, box spring, davenport or day bed, bed spring, metal couch, metal bed, metal cot, metal cradle, used or intended for use for sleeping, resting, or reclining purposes and any glider, hammock or other substantially similar article which is wholly or partly upholstered.

Filling material includes any hair, down, feathers, wool, cotton, kapok, or other soft material used for filling articles of bedding or upholstered furniture.

"New" means any material or article which has not been previously used for any purpose and includes by-products produced in the manufacture of new fabric and material reclaimed from old fabric.

"Secondhand" or "used" means any material or article of which prior use has been made, except as otherwise provided in this article.

"By-products" mean the material known in the cotton waste trade as "sweeps" or "oily sweeps" and shall be named "mill sweepings" on the tag required by this regulation.

"Manufacture" or "make" shall include altering, repairing, finishing, or preparing articles of bedding, or filling materials for sale, including remaking or renovating when done away from the home of the owner.

Permit required

Every person, firm or corporation desiring to operate a sterilization process for the cleaning and sterilization of bedding, mattresses, upholstery, clothes, rugs, kapok, wool, cotton, hair, textiles and all similar material, shall first obtain a permit from the board of health.

Such permit shall be conspicuously posted in the establishment.

Application for such permit shall be accompanied by complete specifications and drawings or prints of the method of sterilization, and means by which this sterilization is to be accomplished.

(Permits are applied for and issued in accordance with the provisions described for Industrial Establishments.)

Investigation and Records

The health officer shall make or cause to be made such studies, surveys, investigations, inspections and visits to bedding, mattress and/or upholstery sterilization establishments governed under the above paragraph as may be necessary to determine that the provisions of this rule and all applicable provisions of the sanitary code are being complied with.

The health officer or his agents shall be permitted to enter upon any premises at all reasonable hours and in an emergency at any time for the purpose of ascertaining the extent of compliance with all provisions of the sanitary code.

The health officer shall make or cause to have made any tests, any chemical or bacteriological analyses of samples, or any measurements, which may be required for the purpose of determining compliance with the requirements and standards for bedding, mattresses and upholstery sterilization or any other applicable provision of the sanitary code.

Every permit holder, and every employee of such permit holder shall furnish such records as may exist and such information or records as may be required by the health officer to ascertain that the establishment is capable of or does comply with the sanitary code.

Standards, Requirements and Prohibitions

The following standards, requirements and prohibitions shall apply:

Specific Prohibition.

No person shall sell as new any article of bedding unless it be made from all new material and be free from dust, dirt or other foreign matter and be tagged as herein stated.

No person shall sell, representing it to be new material any old, second-hand or previously used hair, down, feathers, wool, cotton, kapok, or other material.

No person shall sell any article of bedding made from old or second-hand or used material unless it shall be tagged as herein provided.

The presence of any old or used or second-hand material or article, on the premises of any maker or vendor, shall be presumptive evidence of the sale or use.

No person shall sell any article of bedding, or any material used in the making thereof, which has been used by or about any person having an infectious or contagious disease, unless such article or material shall have been sterilized and be tagged as provided herein.

No person shall make any article of bedding for sale from any material which has not been thoroughly sterilized by a process approved by the board of health if the material:

1. Comes from an animal or fowl.
2. Contains any vermin, insects or filth.
3. Be unsanitary.
4. Contains burlap or other material that has been used for bailing.
5. Be second-hand.

No person shall use any material to make any article of bedding for sale that has been manufactured in unsanitary premises, building, structure or equipment.

Sterilization and cleanliness shall be achieved by one or more of the following:

Loose filling material or bedding or made-up mattresses shall be subjected to direct steam under a pressure of 15 pounds per square inch and maintained at that pressure for a period of at least 30 minutes, or at a pressure of 20 pounds per square inch and maintained at that pressure for at least 20 minutes; or

Loose materials or made-up mattresses shall be subjected to dry heat at a temperature of 230 degrees F., and maintained at that temperature or above for not less than one hour; or

Any process used for cleaning and curing feathers or cleaning and curing hair, or cleaning wool,

or cleaning or curing any other filling material derived from an animal or fowl, shall be deemed to afford proper and thorough sterilization when such process effectually removes all disease-bearing spores or disease organisms, and all dirt, filth, vermin and extraneous organic matter.

Materials shall meet the following test for cleanliness: Allow a 1/2 ounce representative sample of the material to stand in one quart of freshly boiled but cold water for at least two hours and then thoroughly agitate the material. Strain off the water through clean muslin and into a clean container. There shall be no visible sediment nor cloudiness and no cloudiness or offensive odor shall develop in the wash water when allowed to stand for 72 hours in an unsealed container at a temperature not below 72 degrees F.

Tests for spores, disease germs or harmful bacteria shall be by means of bacteriological examination.

All unsterilized secondhand articles or materials shall be separately stored and completely segregated from new or sterilized or clean articles or materials.

No new or clean materials shall be kept or stored within a room or space used for sterilizing secondhand materials.

Any sterilization process used in connection herewith shall be approved by the health officer.

Tags and tagging shall meet the following requirements:
Whenever a tag is required it shall be approved by the board of health and shall be made of muslin, linen or other material of like durability. Paper-faced tags shall not be used. Statements required on tags shall be legibly printed or stamped on one side only, in the English language and in letters at least 1/8 of an inch in height. Tags attached to mattresses or pillows shall be at least 6 square inches in area. The tag required to be attached to an article of bedding or container of filling material shall be firmly and conspicuously attached to the outside of the article in such manner that it cannot be removed without destroying the tag or the means by which it was attached.

Every article of bedding made for sale, sold or offered for sale shall have attached thereto a tag which shall state the name of the material used, that such material is new or old or secondhand, and when required to be sterilized, that such material has been sterilized, and the number of the sterilizing operating permit. Such tag shall also contain the name and address of the maker or the vendor. In addition such tag shall state the percent of such material used with a variance of not more than 10 percent of the amount stated on the tag. No variance shall be allowed for material which is described as "all," "pure", "100 percent" or terms of similar import. In the description of the material used on any tag attached to an article of bedding no term or designation intended or likely to mislead shall be used. Every premises, structure, equipment and facilities governed under "Bedding, Mattresses and Upholstery Sterilization" shall meet the requirements and standards for industrial plants.

Barber Shops and Beauty Parlors

Permit Required

Any person, firm, corporation, agency, institution, group or organization who operates or desires to operate a barber shop, beauty parlor, hair dressing establishment, manicuring parlor, tatooing parlor or any premises or portion thereof used or intended to be used for the business of shaving, clipping, cutting, trimming, singeing, shampooing, massaging, manicuring, dressing, adorning or beautifying the human hair, face, scalp, skin or hands for fee, charge or hire, shall hold an unrevoked permit issued by the health department for the purpose and/or use intended.

(The application and issuance of permits, the investigations and collections of samples, and the provision of reports, records and information by operators are the same as already described under other regulations.)

Standards and Requirements

Any barber shop, beauty parlor and/or any other establishment coming under the definition of these terms shall be officially inspected as often as required by the health officer, but not less

frequently than once per year, and each establishment shall comply with all applicable provisions of the sanitary code and the following:

Every establishment shall be kept clean and in a sanitary condition at all times.

No common article may be used on any person except the temporary cover placed over clothing.

The temporary cover shall not touch any skin about the face or neck and shall have a clean guard for each customer, consisting of a clean cloth, towel, or soft paper wrapped around the neckline.

Hair brushes, combs, shaving brushes and towels shall be clean prior to use on any person, and shall have been disinfected, sterilized or treated in a manner satisfactory to the health officer prior to use on any person, and kept free from contamination until used.

Shaving mugs, brushes and finger bowls shall be thoroughly cleansed and rinsed in hot water after each use thereof.

There shall be as many separate clean towels for each customer as may be required for the treatment of the customer.

The headrest shall be covered with a clean cloth or paper towel prior to use by any customer.

Alum or other material used to stop the flow of blood shall be applied in powdered or liquid form only.

The instruments used on a customer shall be made safe immediately after final use on a customer by washing with acceptable detergent and water, and dipping for one minute in a 10 percent solution of commercial formalin or by treating in some other equally efficient disinfectant acceptable to the health officer.

No powder puff, sponge, or wet duster shall be used in any such establishment.

Soap shall be washed and rinsed after each use and shall be considered a common article unless kept cleaned and rinsed in a manner acceptable to the health officer.

The hands of the operator shall be washed with soap and water before serving each customer.

No operator shall be employed or continue to work in any such establishment who is affected with any venereal disease in the infective stage, or with any other infectious disease in a communicable stage, or with any communicable affection of the skin.

The operator shall have the right to refuse service to a customer affected with a visible eruption, or whose skin is broken out or is inflamed or contains pus.

Whenever any customer affected with any eruption, or whose skin is broken out, inflamed, or contains pus is served:
The attendant shall immediately after handling such customer thoroughly wash his hands with soap and hot water, and disinfect his hands with alcohol (70 to 80 percent), or a solution of corrosive sublimate (1 to 1, 000), or a solution containing phenol of proper strength, or Dakins solution, or some equally efficient disinfectant acceptable to the health officer; and

The instruments used on each customer for shaving, including any brush or cup, shall be thoroughly cleansed and disinfected with an acceptable and efficient disinfectant. Soap shall be discarded and replaced with new soap. Brushes shall be immersed in disinfectant for three minutes.

A clear and easily read printed copy of requirements for tools and equipment, and requirements for customer and operator hygiene shall be posted in each establishment.

Such establishments shall be heated, lighted, ventilated, and shall have adequate sanitary facilities conveniently available to the establishment, and all such provisions shall be acceptable

to the health officer and in conformance with applicable provisions of the sanitary code.

No operator in any establishment shall use any drug, cosmetic, cream, oil, ointment, liquid, powder, or any other substance containing acids, metals or any toxic substance injurious to skin, mucous membrane, eyes, hair, or any such substances toxic to human beings when absorbed through the skin, whenever such substance used in amounts required for the proposed treatment is more than any specific allowable concentration for any such substance approved by the health officer.

The board of health declares that possession of, labelling, offering for sale, or use of dyes containing an aniline derivative or metallic salt or compound as an application on the eyebrows or eyelashes are a nuisance and cause of sickness.

Turkish Baths —Massage Parlors

Permit Required

Every person desiring to construct, or operate a massage parlor or turkish bath, or any such establishment, or any portion of any premises, used or intended to be used as a place where a method of treating the human body by means of water vapor, hot water, cold water, steam, packs, mud, baths, showers, rubbing, stroking, kneading or tapping is employed, shall hold an unrevoked permit issued by the health department for the purpose intended.

(The application and issuance of permits, the investigations and collections of samples, and the provision of reports, records, and information by operators are the same as already described under other regulations.)

Standards and Requirements

Any establishment governed under "Turkish Baths —Massage Parlors" shall conform to all applicable requirements of the sanitary code and in addition to the following minimum requirements:

Every building and structure, or portion thereof occupied shall meet the requirements for hotels insofar as such requirements apply to places or rooms where beds are provided to customers for resting before, during, or after treatment.

Change rooms and dressing rooms provided for use of customers shall conform to the requirements for change rooms and toilet facilities at bathing places.

Work rooms, equipment, appliances, and facilities shall conform to the applicable requirements established under Industrial Establishments for work room atmosphere, ventilation, heating, lighting, housekeeping and sanitation with such specific exemptions as are provided for and necessary in consideration of the particular use of such premises.

The permit holder shall keep, maintain and operate the establishment under permit in such a manner that the health of customers, the health of persons employed therein, and the public health is not endangered in any way, and failure to do so shall be cause for revocation of the permit.

Every person connected with or employed by any massage parlor or any such establishment shall, at the discretion of the health officer, pass medical examination made by a licensed physician approved by the health officer, and shall submit such specimens of body fluids and discharges for examination as the health officer may require.

Notice shall be sent to the health officer immediately by the operator of any massage parlor or establishment in which any case of infectious, contagious or communicable disease occurs, and no person affected by such disease shall be employed in any manner by such massage parlor or establishment.

No person shall use for housing, sheltering, or harboring of its employees or other persons any massage parlor or any such establishment, or cause or permit same to be used as living or sleeping quarters by such employees of other person.

No massage parlor or establishment shall be used for any immoral or indecent purposes whatsoever, and any discovery of any immoral or indecent acts permitted or performed upon the premises shall be sufficient evidence for the immediate revocation of the permit therefor.

Every massage parlor or establishment which is not established, maintained or conducted as herein provided for is hereby declared to be a public nuisance and in addition to any other action herein prescribed shall be abated in a manner as any other public nuisance.

Chapter XXXV

Fundamentals of Refrigeration

One of the basic techniques in food control is refrigeration. The sanitarian can scarcely go through a day's routine without being confronted by the use of refrigeration. The problems of the social uses and the development of the technology of refrigeration are the domain of the engineer. Yet the understanding of the principles of refrigeration and the essence of the mechanical application of refrigeration is necessary to the sanitarian. At times, the sanitarian is called upon as a consultant in such matters by those with whom he routinely deals. He should be able to give simple advice to these people to help in solving simple problems, and to guide them in seeking engineering aid when such is necessary. His prestige and effectiveness in dealing with dairymen, grocer, or restauranteur may swell or sag depending upon how useful he can be in moments of need. Suppose that the sanitarian had just confronted a dairyman who was delivering milk to his customers, and had cautioned him that his milk was insufficiently iced. Responding, the dairyman asked the sanitarian how he could guide himself in estimating the amount of ice necessary to keep the milk below 50° F. during delivery. To the dairyman who has been the subject of the educational efforts of the sanitarian, guidance in this matter from the sanitarian is unquestionably expected. The answer to the problem is quite simple for one who understands how to apply a few simple principles of refrigeration. To refer the dairyman to an engineer would demonstrate an abysmal lack of common sense. It is indeed not too much to expect the sanitarian to be able to answer such questions.

Refrigeration and Cooling are two words for the same action: removal of heat, resulting in the lowering of the temperature. Heat is a form of energy, namely, vibration of the molecules of which a body is composed; the more heat, the more vigorous the vibration. When a hot body is touched by a colder one, some of this vibration will be transmitted to the other body; the first body loses heat, the second body acquires heat. Commonly expressed, heat flows from high temperature to low temperature and in doing so heat energy is passed on. In this respect it is convenient to compare it with other well known phenomena:

Water at high elevation flows from high to low (elevation).
Gas at high pressure flows from high to low (pressure).
Electricity of high voltage flows from high to low (voltage).
Heat at high temperature flows from high to low (temperature.)

In each case, the terms in parentheses denote the quality or condition of respectively the water, gas, electricity and heat, not the amount of each of these entities. It should thus be understood that the word temperature indicates intensity of vibration or movement rather than quantity of molecules.

Heat transmission. Heat can be transmitted from one body to another in three different ways, i.e., by conduction, convection, and by radiation.*

The rate of transmission. The amount of heat transmitted per hour per square foot depends on the difference in temperature per inch thickness and on the material through which the heat passes. Metals, stone, and concrete have high conductivity; stone, concrete, and brick have respectively 10, 8, and 5 times the conductivity of wood; wood has from three to four times the conductivity of cork, celotex, or hair felt. For this reason, walls, floor and ceiling of cold storage rooms are lined with cork and attics are sometimes lined with rock wool.

Measuring heat. The heat condition is measured with thermometers. There are various types of thermometers depending upon their use. The household thermometer can indicate heat conditions varying from freezing to desert heat. Others, for scientific purposes, from freezing to boiling. Industrial thermometers often use electricity instead of mercury or alcohol; and for the ceramic industry and brick ovens, little clay pyramids are used of various composition which collapse when a certain heat temperature is reached. The clinical thermometer is for temperatures closely below and above human body temperature.

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*See chapter on "School Sanitation, Lighting, and Air-conditioning" for explanation of these terms.

The thermometers most commonly used are the Celsius or Centigrade thermometer and the Fahrenheit thermometer.

The Centigrade thermometer indicates the temperature at which water freezes (under normal barometer pressure)as 0^{o}; the point at which water boils under the same conditions, as 100^{o}. Between these conditions there are 100 Centigrade degrees.

The Fahrenheit thermometer shows a temperature of 32^{o} at freezing of water, and 212^{o} at boiling of water; between these conditions are (212-32) 180 Fahrenheit degrees:

Thus: 100 degrees Centigrade = 180 degrees Fahrenheit.

1 degree Centigrade = $\frac{180}{100} = \frac{9}{5}$ degrees Fahrenheit.

1 degree Fahrenheit = $\frac{5}{9}$ degrees Centigrade.

On reading the two thermometers:
The freezing point of water is 0^{o} Centigrade or 32^{o} Fahrenheit.
The boiling point of water is 100^{o} Centigrade or 212^{o} Fahrenheit.

This can be stated as follows in the formulae:
Temperature in Fahrenheit = 32+(temp. in Centigrade x 9/5).
Temperature in Centigrade = (temp. in Fahrenheit - 32) x 5/9.

These formulae can be expressed:
F. (Fahrenheit) = 32+(C. x 9/5).
C. (Centigrade) = (F. - 32) x 5/9.

Examples:

a. The temperature in Death Valley is often 132^{o} F. That in Catania, Sicily, at the foot of volcano Etna, often 44^{o} C. What is the higher? Let us change 132^{o} F. to C^{o}.

C. = (F. - 32) x 5/9
C. = (132 - 32) x 5/9
C. = 100 x 5/9 = 55.5^{o} C.

The Death Valley temperature is higher.

b. The normal body heat is 37^{o} C. What is this in Fahrenheit?

F. = 32+(C. x 9/5)
F. = 32+(37 x 9/5)
F. = 32+66.6
F. = 98.6^{o} F.

c. What would be the corresponding temperature Centigrade for zero Fahrenheit?

C. = (F. - 32) x 5/9
C. = (0 - 32) x 5/9
C. = - 32 x 5/9
C. = -17.77^{o} C.

Absolute Temperature

We have seen that heat is energy, resulting from a condition of vibration of molecules. The less vibration, the less heat. If the vibration stops entirely, there should be no heat at all. We call this condition the Absolute Temperature. This temperature is -273.1^{o} Centigrade, corresponding with 459.6^{o} Fahrenheit, and it has never been reached.

Amount of Heat

Everybody knows that it takes more gas to boil a gallon of water than it takes to boil a pint. One of the units used for measuring the amount of heat is the British thermal unit (B. t. u.) which is the average amount of heat needed to raise the temperature of one pound of water one degree Fahrenheit. (The actual amount of heat varies slightly with the temperature.)

In physics, the unit usually used is the calorie, which is the amount of heat needed to raise the temperature of 1 gram of water 1 centigrade. The kilogram calorie (or large calorie) is also used. It is equal to 1000 calories. 1 B. t. u. = 252 calories, and 1 Kg. calorie is 3.96 B. t. u. or about 4 B. t. u. The standard calorie is measured between 15^{o} and 16^{o} C.

Example: The "heating value" of coal is the amount of B. t. u. that 1 pound can produce. This is about 14, 500 for anthracite. The heating value for natural gas is from 750 to 1500 B. t. u. per cubic foot or about 1100 B. t. u. average. This means that theoretically 1 pound of anthracite can raise the temperature of 14, 500 lbs. of water or 1, 700 gallons, one degree Fahrenheit. It would take 13 cu. ft. of natural gas to do the same.

Specific Heat. It takes more heat for some substances to acquire a certain temperature than others. If you had two pots exactly alike in weight and holding the same amount, one being of wood and the other one of bronze, and you filled with water of the same temperature, then this temperature would have gone down more in the wood vessel than in the bronze. To heat 1 pound of water to a certain temperature takes more than 33 times the heat that 1 pound of mercury would require. The amount of B. t. u. required to raise the temperature of any substance one degree Fahrenheit is called the specific heat. It varies somewhat with the temperature. Some specific heats are given below:

water	1.000 B. t. u. (as per definition)	iron	0.110 B. t. u.
wood	0.450 to 0.650 B. t. u.	gold	0.032 "
ice	0.500 B. t. u.	lead	0.031 "
cork	0.485 "	gasoline	0.530 "
glass	0.160 to 0.200 B. t. u.	methyl alcohol	0.590 "
bronze	0.104 B. t. u.	mercury	0.030 "

Latent Heat

If you put a large piece of ice in a bowl of water and take the temperature of the water from time to time with a thermometer, you would find that the temperature would remain at 32^{o} F. until all the ice is melted. Then it would start to rise.

A lot of heat had been added to the water from the air; yet the thermometer did not show it. This heat had all been used to "melt" the ice, that is, loosen up the molecules of which it consists. The solid mass became liquid.

The heat, in B. t. u. needed to change 1 lb. of a substance from the solid state to the liquid state without change of temperature is called the latent heat of fusion. It varies greatly for different substances:

ice	144 B. t. u.	at 32^{o} F.
aluminum	138	at 1216^{o} F.
gray cast iron	9.9	- - -
lead	10.5	at 620.6^{o} F.
mercury	5.1	at -38^{o} F.

(Handbook of Chemistry and Physics)

If, however, the process be reversed, then the same amount of heat is liberated. If, for instance, we have 1 pound of water at 32^{o} F., and we withdraw by refrigeration 150 B. t. u., then 144 B. t. u. would be liberated in changing the water at 32^{o} F. to ice at 32^{o} F., and the other 6 B. t. u. would cool the ice further by: $6 \div 0.5$ (Specific heat of ice) = 12^{o}; 32^{o} F. - 12^{o}F. = 20^{o}F.

Latent heat of vaporization.

In a similar way, when water placed on a fire has reached the boiling point, a thermometer will show a temperature of 212^{o} F. until all water has boiled away. Here, all heat given off by the flame to the water has been used in making steam. The latent heat of vaporization is the amount of B. t. u. needed to change a liquid to the vapor state at constant temperature and under constant pressure. Here again, it varies with the temperature at which the vaporization occurs:

water	970.2 B. t. u.	(at 212^{o} F.)
ammonia	589.3 "	(at -28.1^{o}F.)
sulphur dioxide	171.0 "	(at 14^{o} F.)
mercury	117.0 "	(at 674.6^{o} F.)

(Handbook of Chemistry and Physics, 25th ed.)

Application of these principles to industrial refrigeration.

We know that water changes from the liquid to the vapor state at a temperature of 212° F., which is about three times the average air temperature, therefore we have to add heat from a burner to do it fast. We could, however, (and it is done in the tropics) let the water trickle slowly over a cotton net hanging down. The air movement will vaporize the water, and in doing so, the air has to give up enough of its heat to raise the molecules of evaporating water to 212° F. This process cools off the air in the room.

Liquid ammonia changes to vapor at a temperature of 33.4° C. under normal air pressure, but if we wished to keep it in a liquid state we would have to compress it. In ice plants and refrigeration plants this is done by special compressors. These compressors not only compress the ammonia, but, by doing so, increase its temperature considerably. This heat should be taken away. It is removed by flowing cold water over the gas coils on a piece of equipment called condensor (Fig. 1): the lowering of the temperature of the gas causes it to become liquid. In this state, it is gathered in a reservoir which holds the liquid ammonia under room temperature.

In an ice plant, the actual ice making is done in cans placed in a large tank filled with brine which freezes, as we shall see later, at much lower temperature than water, and which is circulated under and around the ice cans by means of circulation pumps placed diagonally at two corners of the brine tank. The brine is cooled in a section of the brine tank called "brine coolers," (Fig. 1-a) in which are placed a number of loops of pipe connected with the liquid ammonia reservoir. A valve on the line near the liquid ammonia reservoir, called expansion valve, releases the liquid ammonia which, under normal pressure, exists only as a gas and therefore evaporates instantly. Again heat is needed for this process of vaporization, but the only medium from which the heat can be extracted is the brine, and indirectly the water in the ice cans to be frozen. The amount of gas released is such that, in ice plants, the temperature of the gas in the coils is approximately 5° F. Usually the brine is held at a temperature between 14° and 20° F. The ammonia gas then takes up heat from the atmosphere on its way to the compressors. The cycle then starts all over again as described above.

The cooling water flowing through the condensors is usually pumped back to the roof and cooled by aeration before being used again for condensing the ammonia.

Total Heat

Any substance may accumulate heat in the following order:

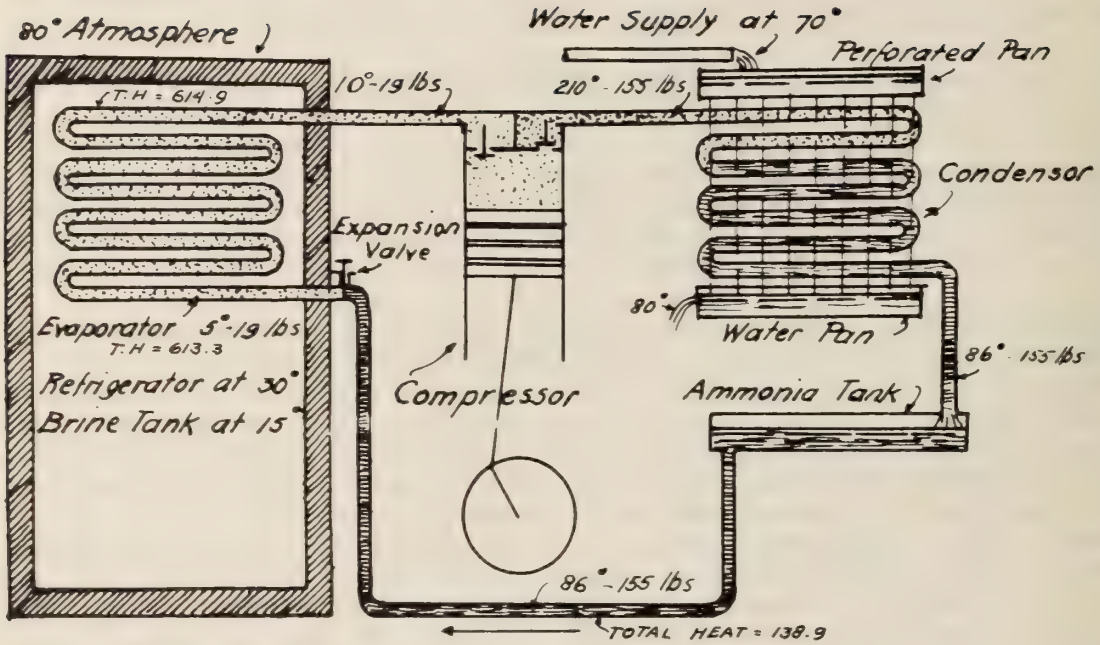
a) Heat bringing the temperature from absolute zero. (-459.6° F.) up to the melting point.
b) Latent heat of fusion under constant temperature.
c) Heating of fluid up to boiling point.
d) Latent heat of vaporization under constant temperature and pressure.
e) Heating of vapor above boiling point temperature.

Under certain conditions there is no fusion, but the substance changes directly from the solid state to the gaseous state. In that case the latent heat of "sublimation" is the sum of the latent heats of fusion and vaporization.

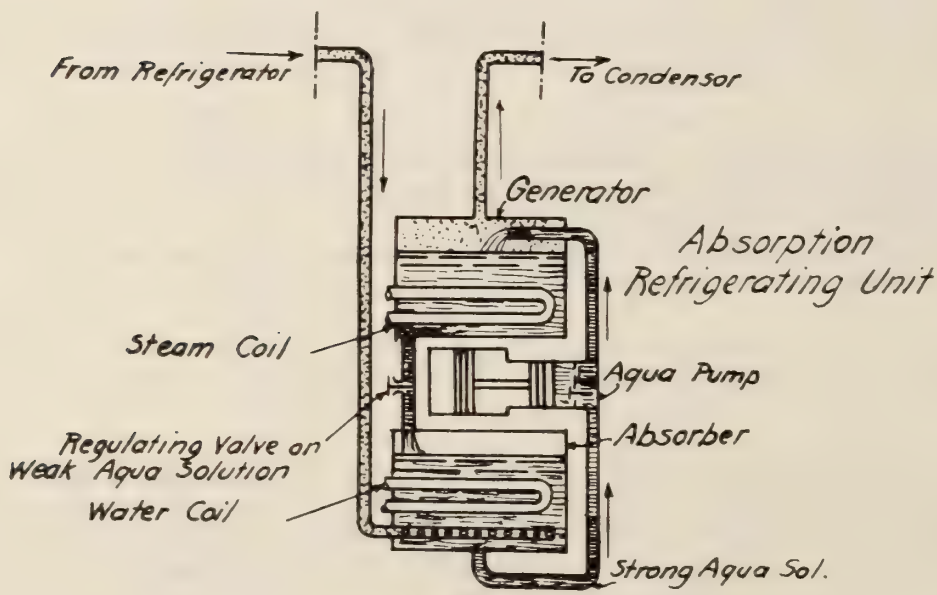
In refrigeration, we do not start this accumulation at the zero temperature, but at -40° F., and we call all heat accumulated above this temperature: the total heat. Because the latent heat of vaporization is so great, the total heat for the same substance is greater for the substance in gas form than in liquid form, even though the temperature of the latter may be much higher. The latent heat of vaporization is much higher than the specific heat times the difference in temperature.

Example: For ammonia in the refrigeration system under pressure (Fig. 1-a), the total heat in B.t.u. per pound is:

613.3 B.t.u. for vapor at 5° F. in the brine cooler at 19 lbs. pressure.
138.9 B.t.u. for liquid at 86° F. in the reservoir at 155 lbs. pressure.
Difference 474.4 B.t.u. = Net refrigeration.



A. Cycle of Compression Refrigerating System



B. Cycle of Absorption Refrigeration System is as shown in top figure, replacing the Compressor by the Absorption Unit.

Fig. 1. Mechanical Refrigeration

Net Refrigeration

The net refrigeration is the heat in B. t. u. absorbed from the brine under operating conditions per pound of refrigerant. For instance, in a plant using ammonia, the liquid ammonia stored in the reservoir and having an average temperature of 86° F. will, after expansion, have an average temperature of 5° F., but it will have gained a total of 474. 4 B. t. u. which has been extracted from the brine. The net refrigeration for the ammonia, then, is 474. 4 B. t. u.

The net refrigeration varies for different refrigerants for these two temperatures, 5° F. and 86° F., as follows:

Carbon dioxide (CO_2)	57. 0 B. t. u.
Butane (C_4H_{10})	123. 5 "
Sulphur dioxide (SO_2)	141. 4 "
Ethyl chloride (C_2H_5Cl)	142. 5 "
Ammonia (NH_3)	474. 4 "

Choice of Refrigerant

It can be shown that, as far as efficiency of the process is concerned, one refrigerant is as good as another. The choice of a proper refrigerant therefore depends on other properties, of which the danger to life in case the refrigerant should escape into the air, and to some extent the corrosive action of the refrigerant on the metals used in the system are examples.

Ammonia corrodes copper and copper compositions; sulfur dioxide corrodes iron and steel if they be not perfectly free from water. Both gasses are painfully harmful to animal life, whereas methyl and ethyl chloride are anaesthetics. Carbon dioxide is practically harmless and non-explosive in all mixtures, therefore, it is frequently chosen for hotel and theatre installations. However, it requires a condensor pressure of 1052 lbs/sq. in. against 169. 2 lbs. /sq. in. for ammonia and 27. 2 for ethyl chloride.

Choice of Brine

As we saw above, the heat is extracted first from the circulating brine which therefore must have a freezing point lower than the temperature of the ammonia gas in the coils. This freezing point depends on the degree of saturation of either sodium chloride (NaCl) or calcium chloride ($CaCl_2$), whatever is used in the particular installation. Since more than 3 times as much calcium chloride can be dissolved in a gallon of water than sodium chloride, the freezing point of the saturated $CaCl_2$ solution is much lower than that of NaCl. Table 1, Percent Solutions and Freezing points is given below (taken from Table 2):

Table 1. Percent Solutions and Freezing Points

Solution %	Freezing point ° F. NaCl	$CaCl_2$
10	20. 2	21. 4
15	12. 4	12. 2
20	2. 4	-1. 0
23	-5. 2	-10. 8
25	13. 2	-18. 0
29	- -	-39. 0
30	- -	-46. 0

In using brine, corrosion should be prevented as much as possible; a density near 1. 2 and keeping it slightly alkaline will accomplish that. Sodium chloride is mostly used in the packing-house industry where air is cooled with a brine spray. In ice plants, where the brine must be kept 10-15° F. lower than the refrigeration itself would require, the use of $CaCl_2$ is indicated. The maximum percentage of added chemical to be used is 23% for sodium chloride (salt) and 29% for calcium chloride (Table 1) the latter because no greater heat circulation is needed. The first mixture amounts to, in weight, 3 pounds of salt to 10 pounds of water, or 15 pounds of salt to every 6 gallons of water. If ice be used instead of water for cooling purposes, 3 pounds of salt to 11 pounds of ice is the maximum amount of salt for best refrigeration.

Ice Plant Equipment

The following equipment is needed for an ice plant using a compressor system: A sanitary water supply, treatment tanks for removal of hardness and iron and excess alkalinity (if needed), filters for the treated water (if needed), storage tanks for treated water (if needed), water circulation pumps for the "ice" making water, a cooling tower or spray pond for condensor water, a recirculation pump for cooling water, ammonia compressor, ammonia condensors, liquid ammonia reservoirs, air compressors, brine cooler, brine tank, brine circulators, expansion valve and other valve gauges and thermometers, a purger to expel air or other non-condensible gasses from the refrigeration system, a number of galvanized steel cans placed in the brine tank, a can filling installation, a can lifting crane, a "dumping vat" to loosen the ice from the cans, a chlorinator (if needed), a number of needles, core suckers and core fillers, an ice storage room, an ice pulverizing machine.

Water Supply for Ice Making

The quality of ice turned out depends much on the chemical condition of the water used. The water should be sparkling clear and free from taste and odor, bacterially pure, free from carbonate hardness (carbonates and bi-carbonates of calcium and magnesium), free from iron and aluminum, and the sulfates, chlorides, and sodium carbonates should be less than 171 ppm. for 1st quality ice, 256 ppm. for good ice, and 342 ppm. for mercantile ice.

The presence of carbonate hardness often makes softening necessary. If this be done with a zeolite softener, the limit of sodium carbonates permissible will often determine whether or not the original water be suitable for use.

Bicarbonates and carbonates of calcium and magnesium will make the ice opaque; oxides of iron and aluminum will turn it yellow.

Wherever the water used for ice making is treated, except by the use of zeolite pressure softeners, it should be chlorinated. If the water be taken from a private well it should be likewise chlorinated unless the well be in an approved sanitary condition. Cross connection between the private supply and the city water supply cannot be tolerated, and should be immediately removed.

Usual Procedure of Ice Making

The part which is played by the refrigerant itself, and the equipment needed therefor has been explained in the foregoing pages.

The actual ice making consists of:

a) The filling of the ice cans with a quantity of water, depending on the size of the cans. Cakes vary from 300 to 400 lbs. of ice. Usually, a can filling tank is placed at the end of the brine tank, near the dipping tank.

b) The cans are then lifted by the crane and placed in position in the brine tank.

c) In the center of each can, one thin copper pipe, called a "needle", is placed. This is connected to a rubber hose which conveys compressed air to the needle which in turn will bubble up constantly, preventing the water around the center from freezing.

d) The cover is replaced on the can.

e) After a certain number of hours, most of the water has been frozen, leaving an elliptica core in the middle. The water in this core contains most of the impurities and salts which had been "frozen out" of the ice around the edges of the can. The needles are then removed.

f) The water is removed from the core by means of a "core sucker", and the hole in the ice is refilled with water by means of a "core filler." The cover is then replaced and the core allowed to freeze.

g) After a period of 40-50 hours (sometimes shorter), the cans are removed and briefly dumped in a tank to defrost the ice from the cans. The cans are then removed and the ice cakes put on the slide leading to the ice storage room. The process is then renewed. The period stated above is for the usual brine temperature of 14-20^{o} F. The use of brine of 0^{o} F. will cut this time in half.

Ice Plant Sanitation*

Besides the important sanitary condition of the private well (if used), and the absence of cross connections with the city water supply, the following points should be observed:

Treatment tanks should be properly covered, and manhole covers kept closed except when used.

Filters should be backwashed at regular intervals depending on water conditions. If paper filters be used, the filter pads should be handled in a sanitary way. Treated water storage tanks and can filling tanks should be kept covered. Needles, core suckers, and filters should be stored on bars and hooks suspended above the can covers. Never should such equipment be hung outside the windows. Can covers should be mopped regularly, likewise the grooves between the covers should be kept free from dust.

Walking over the can covers should be kept to an unavoidable minimum and then, not with shoes used in the street. If chlorination be needed, chlorine residuals should be tested for each batch. Ice in the ice storage room should be stored in a proper way, preferably on a false floor. Never should fish, game, or meat be placed on top of the ice. If stored in the storage room, such foods should be placed in a special closet with a baseboard in such a way that at no time the ice is in contact with the food.

Direct and Indirect Refrigeration

The refrigeration method in an ice plant, as described above, is one in which a medium (the brine) is used to convey the heat from the object to be cooled (the water) to the refrigerant evaporator. The heat is not transferred directly from the water to the refrigerant. The refrigeration is therefore indirect.

In cold storage plants the fluid refrigerant is evaporated in a series of coils placed in or around the room. The stored foods give off their heat to the circulating air which in turn transfers it to the cooling coils. In fact, this method of refrigeration is also indirect; but because the refrigerant coils are located in the space to be cooled, the refrigeration is called direct. Absolute direct refrigeration would only be obtained by placing the foods in shelf coils. Such systems are now rare.

Examples of Direct Refrigeration

The best known example of direct refrigeration is that of homemade ice cream, in which the cream container is placed in a mixture of crushed ice and salt. The salt causes the ice to melt, and the latent heat of fusion needed for this process is extracted from the cream. Temperatures obtainable with this method are listed in Table 1 The old fashioned ice box is also an example of absorption of heat by melting.

The use of "dry ice" (solid carbon dioxide) is an example of heat absorption by sublimation (passing directly from the solid to the gaseous form.) The latent heat of vaporization is 87.2 calories per gram at -60° C. which is very close to the heat of sublimation and is equivalent to 156.5 B.t.u./lb. of dry ice, (i.e., 87.2 kilogram calories per kilogram of dry ice at -60° C. x 3.96 B.t.u. per kilogram calorie ÷ 2.2. lbs. per kilogram = 156.5 B.t.u.) Foods are packed in dry ice and insulated from the air; they furnish the heat of sublimation of the refrigerant.

In dairies the milk is placed as soon as possible in a vat with cold water, in order to reduce the temperature and keep the bacteria count down. This water is kept at a low temperature either by using well water, or by adding ice. This is likewise a case of direct refrigeration.

Cold Storage Plants

In cold storage plants, the individual rooms are cooled by a system of coils placed against the ceilings of the rooms. The air which comes in contact with these coils will be cooled. It shrinks in volume, and becomes denser and heavier. It then sinks to the floor, displacing the other air and causing a continuous circuit of air. While flowing past the stored food, it will absorb heat which in turn is given up to the coils. Likewise, the food will radiate heat to the coils. The coils may be wound spirally, but the usual arrangement is to weave them back and forward with

*See regulations for manufacture and distribution of ice in Chapter on Public Water Supply.

straight pipes connected by U bends. Sometimes these coils are "finned" with thin strips of metal placed vertically around them to increase the contact surface area with the air.

As there is little or no conduction of heat through air, heat-transfer through an air filled space must be by convection or radiation. If the coils were placed on the floor of the room, convection would practically cease (unless fans were used to produce air movement), and the only heat transfer would be by radiation from the stored goods to the coils.

Frost will form on all cooling coils which have a temperature below 32° F., due to the moisture in the air. This will accumulate until it practically insulates the coils from the heat. In that case periodical defrosting is necessary which can be accomplished by various means, such as circulating warm vapor of the refrigerant through the coils for a certain length of time.

Absorption Refrigeration System

This system is based upon the extraordinary affinity that ammonia gas (or liquid) has for water. At 32° F. and 900 mm. pressure (760 mm. = 1 atmosphere), one pound of ammonia can be dissolved in 1 lb. of water, or a volume of about 1300 cu. ft. of gas dissolves in 1 cu. ft. of water at atmospheric pressure. At 80° F. this is reduced by nearly 40%. (The solubility of carbon dioxide at 32° F. is only 0.00335 lb. per lb. of water, of $\frac{1}{300}$ as soluble as ammonia.)

When ammonia is absorbed by water, positive heat is formed i.e., the solution increases in temperature (several chemicals have a negative heat of solution,) so that the ammonia solution, immediately after absorption has a higher temperature than either the ammonia or the water before the absorption.

Let us start at the return line from the brine cooler (Fig. 1-b). This line, in this system, leads into a tank called the "absorber" into which a cool solution of the weak ammonia falls in a continuous spray, absorbing the ammonia, and consequently leaving a low pressure area into which the vapor from the evaporator flows continuously and is absorbed. The heat created by the absorption is taken away by cooling water flowing over the absorber, thereby again increasing the absorbing power of the water which is higher at lower temperatures than at higher ones. As a result a strong solution of ammonia is collected in the bottom of the absorber. Since liquid ammonia is lighter than water, an ammonia solution likewise will be lighter than water, i.e., the stronger the solution, the lighter it will be. This solution is called "aqua."

To be used for refrigeration, the ammonia must be separated from the solution. This is accomplished by raising both the temperature and the pressure of the refrigerant.

The pressure is raised by a pump called the "aqua pump" which is little or no different from any other liquid pump. The aqua pump delivers the ammonia liquor to the "generator." In the generator the temperature is raised, and part of the ammonia driven off by use of steam coils passing through the vessel. After losing this part of its ammonia, the weakened aqua is drained back to the absorber, being cooled on the way by passage through heat exchangers. The ammonia driven out of the aqua —which is still under a high pressure —passes to a condenser. Any water still remaining in the ammonia is taken out on the way to the condenser by two pieces of equipment the "rectifier" and the "analyzer." The removed water is drained to the absorber. From the condenser, the circuit is the same as that for compressor refrigeration. (Fig. 1-a.)

Unit of Refrigeration

The unit of refrigeration is a value which expresses the amount of refrigeration done in a certain length of time. The old unit used to be called the ton of refrigeration, and consists of the melting effect of 2000 lbs. of ice at 32°F. in 24 hours.

The modern unit is the rate of cooling equal to 200 B.t.u. per minute or 12,000 B.t.u. per hour.

It will be seen that both units are alike. The "melting effect" of 1 lb. of ice is 144 B.t.u., this being the latent heat of fusion; therefore that of a ton of ice per hour is equal to 2000 x 144 ÷ 24 = 12,000 B.t.u. per hour.

Table 2. Properties of Brine Solutions

% Solution by Weight	Sodium Chloride					Calcium Chloride				
	(1) Freezing Point, Degree Fahr.	(1) Specific Heat, Degree Fahr.			(2) Pound of salt per Gal. of Sol.	(1) Freezing Point, Degree Fahr.	(1) Specific Heat, Degree Fahr.			(3) Pounds of Chloride per Gal. of Sol.
		14	32	50			14	32	50	
5	26.7	-	0.936	0.938	0.432		-	-	-	
6	25.5	-	0.924	0.927	0.522		-	-	-	
7	24.2	-	0.913	0.916	0.612		-	-	-	
8	22.9	-	0.902	0.906	0.705	24.2	-	0.882	0.887	0.712
9	21.6	-	0.892	0.896	0.799	22.8	-	0.867	0.872	0.807
10	20.2	-	0.882	0.887	0.894	21.4	-	0.853	0.858	0.905
11	18.8	-	0.873	0.878	0.990	19.8	-	0.839	0.844	1.00
12	17.3	-	0.865	0.869	1.09	18.2	-	0.825	0.831	1.10
13	15.7	-	0.836	0.861	1.19	16.3	-	0.812	0.818	1.20
14	14.1	-	0.848	0.853	1.29	14.4	-	0.799	0.805	1.31
15	12.4	0.835	0.841	0.846	1.39	12.2	0.781	0.787	0.793	1.41
16	10.6	0.827	0.834	0.839	1.49	9.9	0.768	0.775	0.781	1.52
17	8.7	0.821	0.827	0.832	1.60	7.4	0.756	0.763	0.770	1.63
18	6.7	0.815	0.821	0.825	1.70	4.7	0.745	0.752	0.759	1.74
19	4.6	0.809	0.815	0.819	1.81	1.9	0.734	0.741	0.748	1.85
20	2.4	0.804	0.809	0.813	1.92	- 1.0	0.723	0.731	0.738	1.97
21	0.0	0.798	0.803	0.807	2.03	- 4.0	0.713	0.721	0.728	2.08
22	-2.5	0.794	0.789	0.801	2.14	- 7.3	0.704	0.711	0.718	2.20
23	-5.2	0.788	0.793	0.796	2.25	-10.8	0.694	0.702	0.709	2.32
24	1.4	0.784	0.788	0.791	2.37	-14.1	0.686	0.693	0.700	2.44
25	13.2	0.779	0.783	0.786	2.48	-18.0	0.678	0.685	0.692	2.56
26	-	-	-		2.60	-22.0	0.670	0.677	0.683	2.69
27	-	-	-			-27.0	0.663	0.669	0.676	2.82
28	-	-	-			-32.0	0.656	0.662	0.669	2.95
29	-	-	-			-39.0	0.649	0.665	0.662	3.08
30	-	-	-			-46.0	0.643	0.648	0.655	3.21

1. Data from O'Rouke, General Engineering Handbook
2. Data from Permutit's Water Conditioning Handbook
3. Chemically pure Commercial $CaCl_2$ has about 25% of moisture

Simple Problems of Cooling Milk

Summary of data required to resolve simple problems of cooling milk:

1) Each pound of ice which has a temperature below freezing (32° F.) will absorb approximately 0.5 B.t.u. for each degree below freezing when warming up to 32° F., i.e., the specific heat of ice is approximately 0.5.

2) Each pound of ice at 32° F., in melting, will absorb 144 B.t.u. This is the latent heat of fusion.

3) Each pound of water, in rising 1° F. absorbs 1 B.t.u., i.e., the specific heat of water is 1.0.

4) The approximate specific heats of milk and various milk derivatives are:

Whey	0.98 for all temperature ranges
Skim milk	0.95 " " " "
Whole milk	0.93 " " " "
15% cream	0.75 at 32° F., and 0.91 above 60° F.* (1)
30% cream	0.67 at 32° F., 0.98 at 60° F., & 0.85 above 140° F.* (2)
45% cream	0.60 at 32° F., 1.0 at 60° F.* (3)
Butter	0.52 from 32° F. to 60° F., and 0.56 at 104° F.* (4)

*Interpolate for the intervening temperatures: (1) An increase of 0.00572 per degree between these temperatures, (2) An increase of respectively 0.0111 between 32° and 60°, and a decrease of 0.00296 between 60° and 104° F., (3) An increase of 0.0143 between these temperatures, and (4) An increase of 0.00091 between 60° and 104° F.

For instance, the specific heat for 15% cream at 48° F. will be 0.75 (48-32) x 0.00572 = 0.75 0.09 = 0.84.

Examples:* Suppose that it is required to cool 1, 000 lbs. of water from 80° F. down to 40° F. using ice at 28° F.

B. t. u. to be removed from 1000 lbs. of water by reducing temperature by 40° F., i. e., from 80° F. to 40° F. is calculated by the formula:

lb. of water x degrees reduced x specific heat = B. t. u., i. e.,
100 x (80-40) x 1. 0 = 40, 000 B. t. u.

B. t. u. to be absorbed by each pound of ice is expressed by formula:

Specific heat of ice x the number of degrees below freezing + latent heat of fusion + specific heat of water x the number of degrees to be raised above freezing, i. e.,

0. 5 x (32-28) + 144 + 1. 0 (40-32) = 154 B. t. u.

Therefore 40, 000 ÷ 154 = 260 pounds of ice needed.

Now suppose that it is required to cool 1, 000 lbs. of milk from 80° F. down to 40° F. using ice at 32° F., the final ice water temperature being 36° F.

B. t. u. to be removed from 1000 lbs. of milk by reducing its temperature by 40° F., i. e., from 80° F. to 40° F. is:

1, 000 x (80-40) = 40, 000 B. t. u.

But milk has a specific heat of 0. 93

Therefore 40, 000 x 0. 93 = 37, 200 B. t. u. to be removed from the milk.

Now how much ice will be needed to absorb 37, 200 B. t. u. ?

The latent heat of fusion of each pound of ice = 144 B. t. u.
The final temperature of the water will be 36° F.
Each pound of water absorbs 1 B. t. u. in rising 1° F.
Therefore in rising from 32 F. to 36F. = 4 B. t. u.
The total heat absorbed by 1 lb. of ice = 144 + 4 = 148 B. t. u.
Pounds of ice required = 37, 200 ÷ 148 = 250 lbs.

* Consult Chapter XXXVII for more problems on refrigeration of milk.

Chapter XXXVI

Making Concrete

Concrete Making, like other special techniques such as refrigeration, must be part of the sanitarian's store of knowledge lest ignorance of these techniques damage his position and render him less effective in his work. Construction with concrete is an engineering technique. The sanitarian, nevertheless, is placed in positions where he must give advice in the building of such items as concrete privy slabs and risers, septic tanks, and other small items related to dairy buildings and slaughter houses. He must therefore know the basic principles of concrete making to the extent that he may be able to give consultation to his clients in these smaller items of construction pertaining to sanitary facilities.

Concrete is a mixture in which a paste of cement and water binds fine and coarse materials, known as aggregates, into a rock-like mass as the paste hardens through the chemical action of the cement and water. Concrete is composed of an active material (cement) and inert materials (aggregates). It can be defined as an artificial stone, cast in place in plastic condition.

Portland cement which is the type now almost universally used in this country was invented around 1824 by Joseph Aspdin. The present Portland cement is a finely pulverized material previously subjected in kiln to high temperatures, and consisting principally of certain definite compounds of lime with silica, alumina, and iron oxide which is capable of hardening into a solid mass through chemical combinations of the various compounds with water.

Mortar is a mixture similar to concrete in which no large size aggregate is used. Fine aggregate or sand includes all particles from very fine (exclusive of dust) up to those which just pass through a screen having 4 meshes to the linear inch. Coarse aggregate or gravel includes pebbles, crushed stone, crushed slag, cinders, burned shale, and other suitable materials ranging from 1/4 inch up to 1 1/2 inches or more in size.

The four principal requirements in making concrete are: 1) Strength, 2) durability, 3) workability, and 4) economy.

The first two are requirements of the finished product; the third is the principal requirement of the plastic product; and the fourth becomes very important as the amount of concrete to be used increases.

A fifth requirement should be added for sanitary installations, namely, density. The concrete should be as impervious as possible for water tanks, sewage tanks, pipes, etc.

Concrete of good quality can be produced by:

1) Using suitable materials.
2) Correct proportioning of materials.
3) Careful mixing of materials.
4) Correct placing of concrete paste.
5) Correct finishing of surface of concrete.
6) Correct curing of concrete.

When the materials for concrete are first mixed together, the cement and water form a paste which surrounds the particles of the aggregate and holds them together in a plaster mass. A chemical action then takes place between the cement and water causing the paste to harden.

One of the most important rules in making concrete is:
The potential quality of the concrete paste is determined by the relative quantity of water mixed with the cement: The so-called water-cement ratio.

If too much water be added, the paste becomes thin and will be weak when it hardens because the particles of the aggregate will not be held firmly together. On the other hand, cement paste which has good binding qualities will hold the particles firmly together, making strong concrete.

Therefore, water and cement are the important ingredients in a concrete mixture.

Using Suitable Materials.

It is important to keep vegetable matter and fine silt out of sand in order to get the best results in making concrete. The colorimetric test is a reliable indicator of the presence of organic matter. The test is performed as follows:

1) Fill a 12 ounce bottle with sand up to the 4 1/2 ounce mark.
2) Add 3% solution of sodium hydroxide (caustic soda) to the 7 ounce mark.
3) Shake thoroughly for 1 to 2 minutes and allow to stand 24 hours.

Readings:

1) If liquid remains colorless, then no organic matter is present.
2) If liquid be straw colored, then some vegetable matter is present, but not enough to be objectionable.
3) If liquid be darker, then sand contains injurious amounts of vegetable matter and should not be used unless washed.

A simple method of washing sand is: Build a wooden incline. Place the material on the higher end of the incline. Water is supplied by a garden hose, pail, or other convenient means. As the materials are washed down the incline, silt, dust, and organic matter separate out and are carried away in the water. Near the bottom of the incline is an opening covered with fine mesh screen (50 meshes to the linear inch) through which the fine particles pass with the water.

Silt Test. Sand and bank-run gravel may be tested to determine whether they contain injurious amounts of finely divided clay or silt, as follows:

1) Place 2 inches of representative sample of sand or gravel in a pint fruit jar.
2) Add water until the jar is almost full. Fasten the cover. Shake vigorously, then set the jar aside until the water clears.
3) Measure the layer of silt covering the sand or gravel. If this layer be more than 1/8 inch thick, the material is not clean enough for concrete unless washed.

It is also necessary that the aggregate-gravel, broken stone, etc., be of good strong materials. Aggregate is tested for soundness by repeatedly saturating the material with a concentrated solution of sodium sulfate and letting it dry. The formation of the sodium sulfate crystals within the mass of an aggregate particle tends to disrupt and burst the particle, and the number of times the aggregate can withstand the process of saturation (simulating the action of freezing and thawing of absorbed water) is an indication of its soundness.

In general, water that is fit to drink is suitable for mixing with cement. The water should be clean and free from oil, alkali, or acid.

Good quality cement depends first of all on the materials from which it is made, and the process by which it is manufactured. The cement must be finely pulverized since only in this state does it react chemically with water. Cement that has been moistened and hardened into cake form is not to be used.

Correct Proportioning of Materials

It has already been stated that the direct relation between strength of concrete and the relative quantities of water and cement in the mixture is expressed by the water-cement ratio strength law: "For given materials and conditions of handling, the strength of concrete is determined primarily by the ratio of the volume of mixing water to the volume of cement so long as the mixture is plastic and workable."

In other words, if 7 gallons of water be used for each sack of cement in a mixture, the strength at a certain age is practically fixed, regardless of what quantities of aggregate are used, so long as the mixture is plastic and workable and the aggregates are clean and made up of sound particles. It should be mentioned here that by "strength of concrete" is meant the strength the concrete has when subjected to compression. The strength of concrete to withstand tension is so small that it

is entirely disregarded, and any tension which may prevail in a concrete structure must be taken by steel reinforcement bars embedded in the concrete.

True Plasticity means a mixture neither too wet nor too dry, and capable of being molded into a dense, compact mass. In over-wet mixtures, the fine aggregates separate from the coarse aggregates. Too dry mixtures cannot be compacted properly. It should be stiff enough to stick together, yet dry enough to be crumbly. When worked over with a trowel, it should be able to stand vertically without flow.

Workable concrete places and finishes readily. In other words, it has just enough cement paste to fill completely the spaces between the particles of aggregate, allowing no honeycombing, and to insure a plastic mix that finishes easily.

A mixture that is workable for one job, may be too stiff for another, that is, concrete to be placed in thin sections must be more plastic than if used in heavier work.

To obtain plastic mixtures, more water is used than can be permanently combined with the cement even with the most extended curing. A certain amount of water, therefore, remains uncombined and distributed within the paste. The space it occupies will become air voids as the water evaporates. Therefore where watertight concrete is needed, less water is used than where watertightness is not so important. The placing of such concrete is more difficult and should be carefully supervised as will be explained later.

In proportioning concrete, the following essential facts should be remembered:

1. Dilution of cement paste with water influences the compressive strength and density of the concrete. Less dilution results in greater ultimate strength and greater density, hence greater durability.
2. Dilution of cement paste permits the incorporation of a greater amount of aggregate, producing a greater volumetric yield of concrete per bag of cement, hence a cheaper concrete.
3. The minimum volume of cement paste included in a mixture should be the amount necessary to fill completely the voids between aggregate particles, completely coat each particle, and separate each particle with a film of paste so as to obtain the desired workability.
4. The fine aggregate content of mixture —that is, all aggregate less than 1/4" size — should be the minimum amount consistent with good plasticity. Small particles have relatively greater surface than large ones, and therefore the greater the surface, the greater the amount of paste needed. For a certain plasticity, the least amount of fine and the most of coarse aggregate is needed to obtain the most economical mix.
5. Shrinkage during setting and volume changes after hardening are higher with the paste content of a mix. As over-sanded mixtures require more paste for a given plasticity, they are more susceptible to shrinkage in surface and volume than those of a minimum sand content.
6. More plastic mixtures require more paste to produce the greater workability, and therefore are more subject to volume changes and shrinkage than dried mixtures.
7. The minimum fine-to-coarse aggregate ratio is that with sufficient fine material to produce a cohesive plastic mixture free from segregation and honeycomb. Therefore, the substitutions of coarse aggregate for fine in a mix of given plasticity is limited in scope.

Sand

For reasons made clear above, good concrete sand should not be too fine. Sand found on sea shores, dunes, or river banks is usually unsuitable for concrete work. It should be well graded, with particles of many sizes from very fine to those which will just pass through a screen of 4 openings per inch (No. 4 sieve), and about half of the weight of the sand would pass through a No.30 sieve. Good concrete sand should have a porosity (volume of interstices) of 43%, and gravel a porosity of 36%.

Sand can absorb a great amount of water and will increase the volume when doing so. A container with a capacity of 1 cu. ft. will hold about 100 lbs. of sand. If dumped on the ground and moistened with water, only a part of the sand — even as little as 75% —could be replaced in the container. This bulking is highest (about 30%) for a moisture content of 8%; with higher moisture,

the bulking decreases to near zero for a condition of complete saturation. Since small changes in moisture may cause large changes in volume of sand, concrete proportioned by volumetric measurement is usually variable in quantity. For this reason, on large constructions the proportioning is done by weight, such as 94:200:350 pounds of cement, sand and gravel respectively.

For minor work, such as septic tank, cistern, etc., with which the sanitarian usually has to do, volumetric proportioning is easier and allowable if proper correction be made for the added water, depending on the condition of the sand. The terms used to indicate the condition of sand are described as follows: Dry Sand flows freely. Damp Sand feels damp to the touch but leaves little moisture; this sand usually contains about 1/4 gallon of water per cubic foot. Wet Sand feels wet and leaves a little moisture on the hands; it contains about 1/2 gallon of water per cubic foot. Very Wet Sand is dripping wet when delivered on the job and leaves more moisture on the hands than wet sand; it carries about 3/4 gallon of water per cubic foot or a little more.

Trial Mixtures

The Portland Cement Association suggests the following concrete mixes to be used with average moist sand and for average conditions. (See Tables 1 and 4.) If sand be very wet, decrease amount of water by 1 gallon per sack of cement. If sand be dust dry, increase amount of water by 1/2 gal. per sack of cement. Change proportions of sand and gravel slightly if necessary to get a workable mix.

Table 1. Suggested Concrete Mixes

Use of Concrete	U.S. gal. of water per sack cement with average moist sand	Sand and gravel per sack cement		Largest size of gravel
		Sand cu. ft.	Gravel cu. ft.	
Most farm construction as floors, steps, basement walls, walks, yard pavements, silos, grain bins, water tanks, etc.	5	2 1/4	3	1 1/2 in.
Concrete in thick sections and not subject to freezing. Thick footings, thick foundations, retaining walls, engine bases.	5 1/2	2 3/4	4	1 1/2 in.
Thin reinforced concrete such as milk cooling tanks, fence posts, thin floors, most uses where concrete is 2 in. to 4 in. thick.	5	2 1/4	2 1/2	3/4 in.
Very thin concrete such as top course of 2-course floors and pavements, concrete lawn furniture, most uses where concrete is 1 in. to 2 in. thick.	4	1 3/4	2 1/4	3/8 in.

The Standard Specifications for Concrete and Reinforced Concrete of the A.S.C.E. and other affiliated organizations have recommended in their 1944 Progress Report, that the water content in gallons per bag of cement be limited on the exposure condition. For ordinary exposed structures this water content in climates of wide range of temperatures, and freezing spells, is 6

gallons for thin sections reinforced, and 6 1/2 gallons for moderate sections reinforced. For milk climates where snow or frost are rare, these figures are respectively 6 and 7 gallons per sack of cement. For concrete exposed to strong sulfate ground water or other corrosive liquids or salts (as in sewer pipes, septic tanks), the maximum water content should not exceed 5 gallons per sack (which is the average figure adopted by the Portland Cement Association). For pavement slabs, directly on the ground, 5 1/2 gallons are recommended.

If the trial mixture be too wet, add small amounts of sand and coarse aggregate in the specified proportion until the right workability is obtained.

If the concrete be too stiff and appears crumbly, succeeding batches are mixed with less aggregate. Usually, slightly less coarse material will give the required workability.

Table 2. Approximate Amounts of Materials Required Per Cubic Yard of Concrete* for the Mixes Proposed in Table 1

Use of Concrete	Sacks of cement	Sand cu. yd.	Gravel cu. yd.	Largest size of gravel
Most farm construction such as floors, steps, walks, tanks, silos, etc. 1: 2 1/4: 3 mix	6 1/4	2/3	3/4	1 1/2 in.
Concrete in thick sections and not subject to freezing. Thick footings and foundations, etc. 1:2 3/4: 4 mix	5	2/3	3/4	1 1/2 in.
Thin reinforced concrete such as milk cooling tanks, fence posts, slabs 2 in. to 4 in. thick. 1: 2 1/4: 2 1/2 mix	6 1/2	2/3	3/4	3/4 in.
Very thin concrete as for lawn furniture, top course of 2-course floors, concrete 1 in. to 2 in. thick. 1:1 3/4: 2 1/4 mix	8	2/3	3/4	3/8 in.

1 sack of cement = 1 cu. ft. weighing 94 lbs.

*Amounts of sand and gravel required for the work should be increased about 5 to 10 percent to allow for waste and variables.

Table 3. Approximate Amounts of Materials Required Per 100 Square Feet of 1:2 1/4: 3 Mix Concrete**

Thickness of concrete, in.	Concrete cu. yd.	Sacks of Cement	Sand cu. yd.	Gravel cu. yd.
4	1 1/3	7 3/4	3/4	1
6	2	11 2/3	1	1 1/3
8	2 1/2	15 1/2	1 1/3	1 3/4
10	3	19 1/3	1 3/4	2 1/4
12	3 3/4	23	2	2 2/3

**Amounts of sand and gravel required for the work should be increased about 5 to 10 percent to allow for waste and variables.

Table 4. Approximate Amounts of Materials Required per 100 Sq. Ft. of Portland Cement Mortar or Concrete

Thickness of Mortar or concrete, in.	Amount of mortar or concrete, cu. yd.	Mix Proportions				
		1:3		1: 1 3/4:2 1/4		
		Sacks of cement	Sand cu. ft.	Sacks of cement	Sand cu. ft.	Gravel (3/8 in.), cu. ft.
3/8	1/8	1	3	. . .	. . .	. . .
3/4	1/4	2	6	. . .	. . .	. . .
1	1/3	2 3/4	8	2 2/3	6	7
1 1/2	1/2	. . .	. . .	4	8	10
3	1	. . .	. . .	8	16	19

C. W. Dunham, of the Port of New York Authority, has prepared the following table as a guide to the proportioning of concrete for minor work on the basis of damp weights (average moisture condition 5% for sand, 1% for gravel):

Table 5. Weights of Materials for Concrete

Total water; gallon per bag	Probable Strength; pounds per sq. in. in 28 days	3/4 to 1 inch coarse aggregate					1 1/2 to 2 inch coarse aggregate				
		Cement lb.	Fine aggregate, lb.	Coarse aggregate, lb.	Mixing water, gal.	Cement factor, bags per cu. yd.	Cement, lb.	Fine aggregate, lb.	Coarse aggregate, lb.	Mixing, water gal.	Cement factor, bags, per cu. yd.
5	4,250	94	147	233	3.8	8.0	94	158	273	3.7	7.4
5 1/2	3,700	94	169	263	4.1	7.2	94	179	303	4.1	6.7
6	3,300	94	200	273	4.4	6.5	94	210	334	4.3	6.0
6 1/2	3,000	94	221	314	4.6	6.0	94	242	364	4.6	5.5
7	2,750	94	253	334	5.0	5.6	94	253	394	5.0	5.1
7 1/2	2,500	94	274	359	5.3	5.2	94	290	420	5.2	4.8
8	2,500	94	295	384	5.7	4.9	94	316	445	5.5	4.5

Proportions for Economy

Adherence to the water-cement ratio method will control strength, but may not result in economical concrete. For many smaller structures such strength is not needed, and considerations of economy or density will prevail.

As stated before, to secure a dense, impervious concrete, it is essential that all surfaces of the particles of aggregate be thoroughly coated with cement paste and all voids filled. It can be readily seen that to secure economical concrete using as little cement as possible (since cement is the expensive element in concrete), it is necessary to select an aggregate with a low surface area and as few voids or air spaces as practical.

Sand and gravel consist of the same basic material, viz: silicates like quarts, granite, etc., and have the same specific weight of 2.65. Since one cubic foot of dry sand weighs between 90 and 100 lbs. (depending on size), and one cubic foot of gravel between 100-120 lbs. (likewise depending on size), it is evident that there is a greater percentage of voids in sand than in gravel, and the larger the particles of each, the less voids.

It must be remembered that in a given volume of aggregate, the larger the particles, the smaller will be the total surface to cover per unit of mass; also, the more spherical the particles the more the voids, and the more cubical the particles the less the voids. But since a good deal of the aggregate particles are spherical more or less, the use of aggregate made up of large

particles will give a smaller surface for the paste to cover but it will leave many voids. To reduce the voids as much as possible, aggregates composed of smaller particles should be intermixed. Therefore, an economical aggregate is one which is composed of particles ranging in size from the largest allowable for the job at hand down to finer sizes. Such an aggregate will have the desirable combination of low percentage of voids and low surface area. However, the amount of coarse aggregate which can be used is often limited by the amount of exposed surface of the concrete where appearance is important rather than by the economy of mixture. The larger the exposed surface and the thinner the layer of concrete the more it becomes necessary to limit the amount and size of coarse aggregate.

In order to preserve quality and increase the quantity of concrete made from each sack of cement, it is desirable to increase the aggregate in correct proportions. Experience has shown that for average jobs, and with coarse aggregate ranging from 1/4" to 1 1/2", the proportion of aggregate should be about 40% sand and 60% coarse aggregate by weight. Generally, a slightly over-sanded mix is the most desirable.

For coarse aggregate ranging from 1/4 inch to 3/4 inch, about 50% sand and 50% coarse aggregate by weight should be used.

All materials including water should be accurately measured if a mix by volume be used. Aggregates can easily be measured by using a bottomless box made to hold exactly 1 cubic foot or any other volume. The box is placed on the mixing platform and filled. When the box is lifted the contents remain on the platform. Measuring may also be done by pails, shovels, wheelbarrows, or by weight. The important factor is to be accurate.

Careful Mixing of Materials

Whichever way mixing is done, it should continue until every pebble or stone is completely coated with a thoroughly mixed mortar of sand and cement. Mixing is done by hand, or by machine. The latter is displacing hand mixing. Mixers of 1, 1/2, or 1/3 cu. yd. batch content are on the market or can be rented; also, in the cities, concrete can be bought ready-mixed to be poured on the job.

The usual procedure of mixing concrete by hand is as follows: The measured quantity of sand is spread out evenly on the platform. On this, the required amount of cement is dumped and evenly distributed. The cement and sand are then turned over thoroughly with No. 2 square pointed shovels enough times to produce a mass of uniform color, free from streaks of brown and gray. Such streaks, when present, indicate that the sand and cement have not been thoroughly mixed.

This mixture is spread out evenly over the platform and the required quantity of pebbles or broken stone is then measured and spread in a layer on top. The materials are again mixed by turning with shovels until the pebbles have been uniformly distributed throughout the mixture of cement and sand. At least three turnings are necessary.

A depression or hallow is then formed in the center of the pile, and the proper amount of water added slowly while the materials are turned in toward the center with square pointed shovels, this turning being continued until the cement, sand, and pebbles have been thoroughly and unformly combined, and the desired workability and smoothness obtained as tested with a trowel.

Correct Placing of Concrete Paste

Moving concrete a considerable distance after mixing and before placing is never desirable because segregation of the coarse from the fine particles may occur. A rather stiff consistency usually is required to prevent segregation.

All debris should be removed from forms, and the forms should be thoroughly wetted before placing of concrete. Concrete should be placed in the forms as soon as possible and in no case more than 45 minutes after mixing.

Concrete should be deposited in level layers not more than 12 inches deep, and tamped and spaded enough to make it settle thoroughly and produce a dense mass snugly fitting into every space of the form to remove air pockets. Tapping the forms with a hammer will be beneficial. On large jobs vibrators are often used for this purpose.

At the end of a day's work or where the work has to stop long enough for the concrete to begin hardening, roughen the top surface just before it hardens to provide a good bond for the next layer of concrete. Just before resuming concreting, the roughened surface should be cleaned and brushed with a cement-water paste of a thick, creamy consistancy. The paste should be applied in a thick-brush coat just a few feet ahead of the concreting operation so that it does not have a chance to dry before it is covered with concrete.

Waterproof Concrete

"Waterproof", in the case of concrete, is a misnomer since waterproof concrete does not exist. Water-resistant or watertight would more closely define this type of concrete.

Concrete can be porous for several reasons:

1. The aggregate used itself is porous.
2. Too much water had caused formation of pores in the cement paste after hardening.
3. Hair cracks formed by shrinkage which in turn was caused by an overdosage of cement paste (being worse in northern states by "infreezing").
4. Prevalence of "laitance", a porous, chalky material in the concrete. This is caused by excess water and too fine or dusty aggregate, or both. Concrete placed on this laitance will fail to bind, and seepage will readily take place along "day-work" joints.
5. Effect of temperature, especially in thick concrete structures. Leakage of water in concrete will increase the porosity and in time cause its disintegration. Concrete, therefore, to insure durability, should be made as watertight as possible.

Given the causes for leakage in concrete, its prevention can be summarized as follows:

1. Use proper materials: clean, graded sand; hard, durable stone; standard fresh cement; clean water.
2. Use proper proportions of proper materials; avoid arbitrary proportions; compensate for variations in materials by variation of proportion; use a minimum of water.
3. Properly and adequately mix the materials, as described above.
4. Place carefully in forms avoiding segregation of materials.
5. Expel secluded air by puddling, vibrating and tapping.
6. Fill forms continuously to top, preferable overflowing to avoid laitance planes.
7. Protect concrete against rapid evaporation, great heat, or frost during setting, hardening, and airing periods.
8. Remove visible segregations as soon as discovered, replacing with good concrete well rammed in place.
9. Construct expansion or contraction joints with extreme care where needed. (Only for long walls and exposed floors).

So called "integral waterproofing", i.e., mixing certain chemicals with the aggregate, should not be practices as it cannot be relied upon to avert the consequences of improper manufacture of the concrete.

The Portland Cement Association gives the following table for good watertight mixes:

Table 6. Watertight Mixes

	Sand lb.	Gravel lb.	Water* gal.	Sand lb.	Stone lb.	Water* gal.
			1 inch aggregate			
5 gal. concrete	180	255	4.2	180	205	4.2
6 gal. concrete	230	315	4.9	230	255	4.9
7 1/2 gal. concrete	290	405	6.2	295	330	6.2
			2 inch aggregate			
5 gal. concrete	180	330	4.2	185	270	4.2
6 gal. concrete	230	410	4.9	230	335	4.9
7 1/2 gal. concrete	290	520	6.2	290	425	6.2

*Water to be added to batch corrected for 4% moisture in sand.

It furthermore states that for such structures as tanks and reservoirs, the concrete should contain no more than 6 gallons of water per sack of cement. Proper length of curing is emphasized; 6 gallons concrete should cure about 9 days and never less than 7 days.

Correct Finishings of Surface of Concrete.

Concrete is leveled carefully just after it is placed in the forms. This removes all humps and hollows leaving a true, even surface for the final troweling operation.

Smooth finishes are produced with a steel trowel, care being taken to prevent too early troweling or excessive troweling which are likely to result in surfaces that will dust or develop numerous fine cracks called hair cracks.

The time of final finishing is important. If the concrete be allowed to stand until it is stiff but still workable, the steel trowel will compact the concrete and produce a dense surface without drawing the cement and fine material to the surface.

A wood float is useful in making an even yet gritty, non-slippery surface for sidewalks, driveways, and floors after the freshly placed concrete is leveled flush with the top of the forms by means of a strikeboard which is worked back and forth across the surface with a slow, sawlike motion. A straight 2 x 4 of convenient length —up to 10 feet for large floors —makes a convenient strikeboard. Final finishing is delayed until the surface has become quite stiff. A final finish on driveways, pavements, and similar work can be produced with a belt of wood, canvas, or rubber not less than 6 or more than 12 inches wide, and at least 2 feet longer than the width of the slab being finished. This is laid on the surface of the concrete immediately after the wood float has been used. For the first application, vigorous strokes crosswise (12 inches long) of the slab are used, advancing slowly forward along the slab as the surface is made smooth and even. The second application of the belt is done by strokes not more than 4 inches, and the movement along the slab slightly greater than for the first belting.

Surface water should be avoided. However, when there is a small amount present, it should be allowed to evaporate before finishing. If there be considerable water, it should be removed with a broom, belt, float, or other convenient means. It is never good practice to sprinkle dry cement or a mixture of cement and fine aggregate on concrete to take up surface water, since such fine materials form a layer on the surface that is likely to dust or hair-crack when the concrete hardens. Tests have shown that a considerable increase in watertightness of the concrete is obtained when the green concrete, after two or three days, is vigorously polished with a flat polishing stone and then allowed to harden. This process closes the pores and forms a watertight film on the surface of the concrete.

Correct Curing of Concrete

The chemical action between the water and cement continues so long as temperatures are favorable and moisture is present to hydrate the cement. Watertightness, durability, and strength of concrete increases with age due to the continued chemical action.

Moist curing greatly increases the strength and watertightness of concrete. Heat increases the rate of hardening.

Wet burlap, canvas, sand, or straw coverings are often used to protect newly placed concrete. This is particularly necessary if the cement be exposed to sunlight or air movements. The covering is placed as soon as it can be done without marring the surface. Care should be taken to keep the covering continuously wet by sprinkling. When a cover is not used, wetting of the concrete should be begun as soon as possible after finishing, and the surface should not be permitted to dry during the curing period.

Ponding is a good method of curing for flat surface. With this method, the surface to be cured is surrounded by small earth dikes and then kept flooded with water for several days.

Walls and other vertical surfaces can be protected by leaving the forms in place temporarily, or by hanging canvas or burlap over them. Such coverings are kept constantly moist by sprinkling.

Curing should continue for at least 7 days, and for longer periods if necessary. For instance, curing for about 10 days is needed to obtain a watertight concrete when 6 1/2 gallons of water are used, 14 days when 7 1/2 gallons are used.

In cold weather, concrete must be protected against freezing. In early winter, when freezing temperatures occur only at night, it is necessary merely to protect concrete from freezing after it is placed. As the weather grows colder and freezing temperatures prevail, the mixing water and aggregates are heated and the work protected.

Equipment

Most of the tools required in concrete work are simple and many of them can be home-made. The principle ones are the following:

1. Screen
2. Mixing Platform
3. Square pointed shovels
4. Measuring box
5. Water barrel
6. Pails
7. Hose
8. Tamper
9. Spading tool
10. Strikeboard
11. Wood float
12. Steel trowel
13. Edger
14. Groover
15. Wheelbarrow
16. Small wire brushes
17. Straight edge
18. Measures (gallon & quart)

A sand screen should be 2 ft. 6 in. or 3 ft. wide, and 6 ft. long. The frame may be made of 1 1/2 or 2 in. lumber, 4 to 6 in. wide. Legs should be so attached to the sides that the screen can be set at the desired angle while throwing material upon it to separate the sand from the pebbles. This angle should be about 45 degrees. A piece of wire cloth or fabric having 4 meshes to the linear inch should be nailed to the frame. Material to be screened is thrown with a shovel against the upper portion of the screen and, in rolling down, the coarse aggregate is separated from the fine aggregate.

For hand mixing, a watertight mixing platform at least 7 ft. wide by 12 ft. long should be provided. A platform of this size is large enough to permit two men using shovels to work upon it at one time. It may be made by using a piece of sheet steel about 1/8 in. thick with 2 by 4's set on edge and properly fastened to three of the form edges or sides of the steel; or the platform can be made entirely of wood. In this case the floor of the platform should be of not less than 1 1/2 in. lumber, 4 to 6 in. wide, tongued and grooved, and surfaced. If tongued and grooved lumber be not obtainable, the edges of the boards should be planed or jointed so that they can be nailed closely together on three 4 by 4 in. stringers, placed 2 ft. or more apart, to make a firm, unyielding platform. Two by four strips should be nailed to three sides so that materials will not be shoveled off the board in mixing.

The measuring box is necessary to measure exact quantities of sand and pebbles or broken stone. Such a box is a bottomless frame made of 1 or 1 1/2 in. material and should have a capacity of not less than 1 cu. ft. If larger, it should be of 2 or 3 cu. ft. capacity, and should be marked on the inside to show levels at which volume will equal 1 cu. ft., 2 cu. ft., etc. Handles are placed on the side of the box to make lifting easy after the material required has been measured.

Table 7. Dimensions for Bottomless Measuring Boxes

Capacity in Cu. Ft.	Inside Measurements in Inches		
	Length	Width	Height
1	12	12	12
1 1/2	15	15	11 1/2
2	18	18	10 5/8

For transferring concrete from the mixer or mixing platform to the place of final use, a wheelbarrow may be needed. One with a sheet iron body should be used having the front of the

body higher than the back to prevent loss of concrete when the barrow handles are raised in position for wheeling. Boards should be laid along the distance from the mixing platform to the place of pouring for easier handling of the wheelbarrows.

When placing concrete in forms, it must be spaded and tamped. A tamper may be made by boring a 1 1/2 inch hole in the end of an 8 by 8 by 12 inch piece of timber and inserting a handle about 4 feet long. A metal tamper may also be used, or one can be made of concrete.

A spading tool of some kind is necessary to settle the material in the forms properly, and also to secure a surface finish free from pebble pockets. Such a spading tool may be made by flattening an ordinary garden spade or by straightening out an old garden hoe. Both tools are used by working them up and down in the concrete close to the form faces so as to force back coarse particles and bring sand-cement mortar to the form face.

Sometimes a chisel-edged board 4 to 6 inches wide may be used for spading concrete, the upper end being shaped to form a convenient handle. When reinforcing metal is placed in the concrete, smaller spading tools will be needed to work in the smaller spaces. Pointed sticks, steel rods, or narrow chisel-edged pieces of wood are used for this purpose.

A strikeboard is, as mentioned, a piece of 1 1/2 or 2 in. lumber, 4 inches or more wide, and long enough to rest across the top of the form, as in sidewalk construction, so that the top of the concrete can be approximately leveled before final finish.

A wood float is used to finish the surface of the concrete after it is struck off, as in building walks, pavements and floors. This is a simple tool and can be made by anyone.

A steel hand float or trowel may sometimes be required where a smoother surface is desired than can be obtained with the wood float.

For finishing joints between slabs in walls, floors, and similar concrete work, a tool known as a groover is used, while for finishing the edges of the slabs the tool used is known as the edger.

A water barrel and pails are necessary for adding the required amount of water to the correctly measured materials.

Most of the batch mixers in use have revolving drums with fixed blades inside, though a few have fixed drums with revolving blades or paddles. The latter type is commonly used in block manufacture where very dry mixes are employed. The drums may be shaped like cylinders, double cones or cubes. Several manufacturers of concrete mixers make machines that are relatively cheap and at the same time very efficient.

The speed of the drum is important. If it rotates too fast, the materials will tend to be held next to the rim, while if the speed be too slow, thorough mixing will not be accomplished in the usual time. A peripheral speed of about 200 ft. per minute is satisfactory.

Forms for Concrete Work

A discussion of concrete form work is beyond the scope of this book. However, an excellent description of the necessary forms for tanks, walks, and similar small structures is given in "Concrete Handbook of Permanent Farm Construction," distributed by the Portland Cement Ass'n. Forms for a septic tank are given in "Concrete Structures for Farm Water Supply and Sewage Disposal" from the same source.

Reinforcing of Concrete

Reinforcing of concrete belongs to the field of a structural engineer and, as such, does not belong in this book. However, an understanding of the basic principles of steel reinforcing should be useful to the sanitarian. Too often the placement of this reinforcement from otherwise correct plans is badly bungled by untrained workmen where proper supervision is lacking, and sometimes

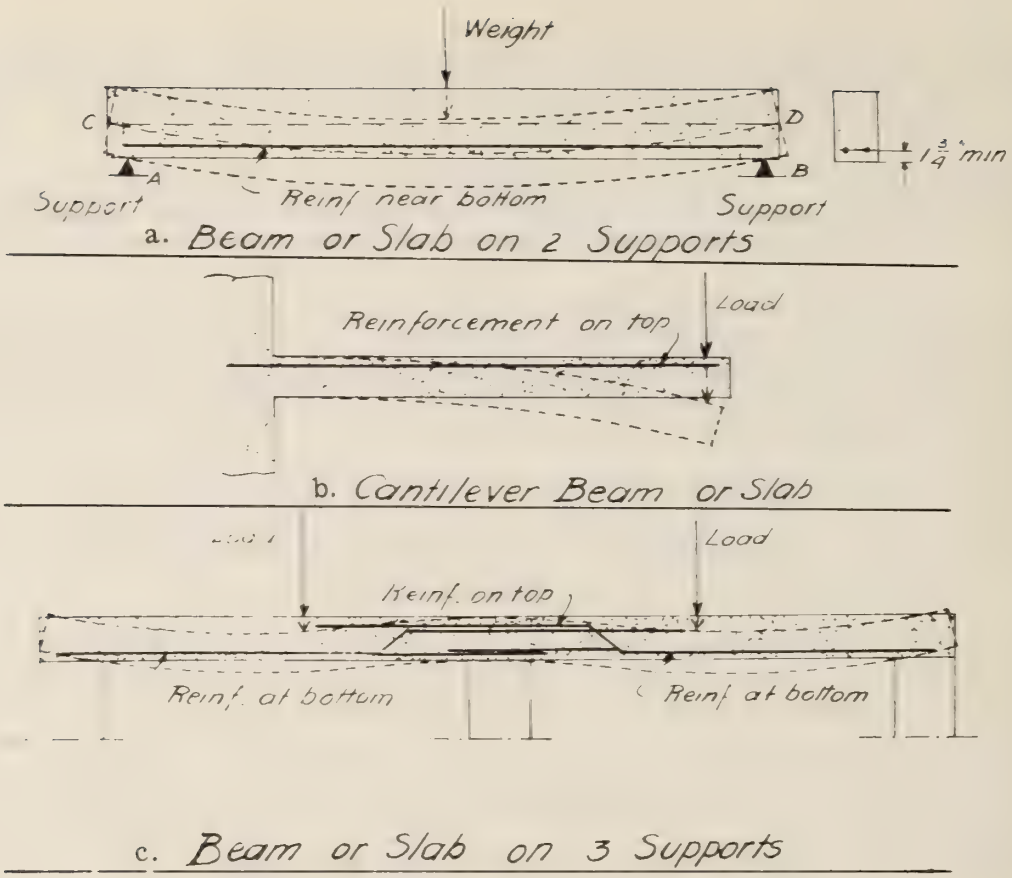


Fig. 1. Location of Steel Reinforcement

leads to the collapse of the structure. Gross errors made in this way can be easily detected by the sanitarian if the following be kept in mind.

It has been stated before in this chapter that concrete is a material which can resist no tension (pull), and that such parts of the structure which are under tension should be reinforced with steel bars embedded in the concrete. If this be done correctly, the concrete forms a chemical bond with the steel. Another important fact is, that both steel and concrete have about the same linear expansion when heated so that differences in temperature under a hot summer sun or under freezing weather do not tend to disrupt this bond. Such bars should be well protected by a layer of concrete at least 1 1/2 inches in order to remain free from corrosion due to infiltration of rainwater. For this reason, in slabs or walls 3 and 3 1/2 inches thick, the reinforcement should be placed in the center; in that case it acts only as a skeleton, and when needed, also as a temperature equalizing grid. In heavier slabs and beams, they should be placed in that part of the cross section which is under tension, as explained in Fig. 1. Suppose we place a beam or slab of wood on two supports A and B, Fig. 1a. If we neglect the weight of the beam, the center line C D will be straight. Now a heavy weight is placed on the beam which sags down so that the top is a hallow curve and the bottom bulges out. Evidently the bottom curve is longer than the curve now formed by C D which in turn is longer than the top curve. As it can be shown mathematically that the length of the curve now formed by C D in the loaded beam is the same as that of the original straight line C D unloaded beam, it is evident that the lower half of the beam (that of the bulge) is stretched and the upper half compressed. If the beam be made out of concrete, the lower half therefore would be unable to stand the tension, and steel reinforced bars would have to be placed as close as possible (a minimum of about 1 3/4") to the outside of the beam.

Steel reinforcement should, therefore, be placed at that side which the forces, acting on the structure, would cause to bulge out.

Other examples: A balcony leading out from a wall would bend down as shown in Fig. 1b.

The bulge is here on top, therefore the steel should be placed near the top.

A floor is placed over three walls, as shown in Fig. 1c . which will be bent under the weights of people and furniture as indicated by the dotted lines. We see that there are two bulges at the underside between the walls, and another bulge at the top over the middle wall. Between the walls the reinforcement should be near the bottom, and over the wall, near the top of the slab. To make this easier, part of the bars are usually bent up to serve both purposes.

If a rectangular tin box be filled with water, it will be seen that the walls bulge out everywhere and thus have to be reinforced near the outside in a vertical and horizontical way. Now, if that same box, empty, were pushed under water the bulges would be at the inside. Both conditions are possible in concrete tanks which are partly or wholly underground, and those tanks have to be reinforced at both inside and outside of walls and bottom, unless, like the one-family septic tank, they be so small that they be strong enough without steel reinforcement.

Chapter XXXVII

Methods of Working Common Problems for the Sanitarian

A simple method for calculating the results of mixing two solutions of various quantities (i. e., in terms of volume or weight) but which have different qualities (i. e., in terms or more or less percentage, more or less ppm., more or less temperature, and the like) may be accomplished in a simple manner if certain rules are adhered to. This method is called the Van Hasselt hexagon method.

Let us consider the following examples:

1. How many pounds of 40% cream should be added to an unlimited supply of 3% milk to produce 1000 pounds of 4% milk.

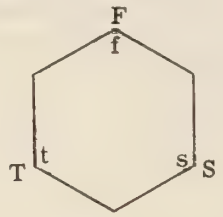


Fig. 1.

F = the quantity of the first batch.
S = " " " " second or diluting batch.
T = " " " " total or result of mixing F and S
f = the quality of the first batch.
s = " " " " second batch.
t = " " " " total or resultant mixture.

The first rule is to place those numerals representing quantity in any problem at the outside alternate corners of the hexagon, and the corresponding numerals, representing quality, adjacent to and at the inside alternate corners of the hexagon, in the order shown in Fig. 1. The numerals of ex. 1. thus placed are shown in Fig. 2.

In this case, all three qualitative numbers are given, i. e., the three percentages of butterfat, but only one quantitative number, i. e., the 1000 pounds of total (T) mixture. The problem is to determine the other two quantities (F and S). The next step to be taken is the second rule.

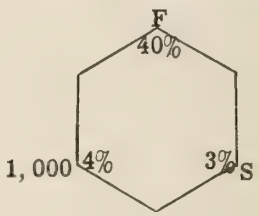


Fig. 2

The second rule is to subtract quality s from quality f and to place the result at the outside corner between S and F; subtract quality s from quality t and place the result at the outside corner between S and T; and subtract quality t from quality f and place the result at the outside corner between F and T. The numbers thus obtained have the character of quantity.

Now let us apply this to our hexagon as shown in Fig. 3.

40 - 3 = 37
4 - 3 = 1
40 - 4 = 36

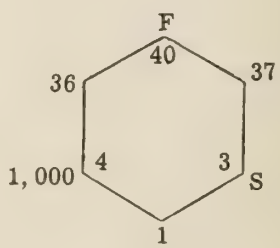


Fig. 3

The problem requires us to find "how many pounds of 40% cream should be used." This is the unknown and is symbolized on the hexagon as F. Now we apply the third rule.

The third rule is to seek out two parallel sides of the hexagon, 3 of whose ends form corners of the hexagon where the quantities are known, and the 4th end of which forms the corner of the unknown qualtity. Then form an equation by multiplying the two quantities of one of the parallel lines and equating this to the product of the two quantities of the other parallel line. The two parallel lines to be chosen in the above problem are shown as heavy lines in the hexagon of Fig. 4.

$37 \times F = 1000 \times 1$

$37F = 1000$

$F = \frac{1000}{37} = 27$, i. e., 27 lbs. of 40% cream are needed.

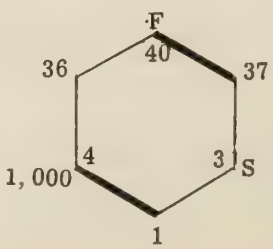
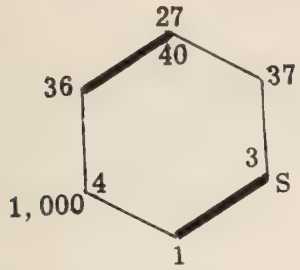


Fig. 4.

If 27 lbs. of 40% cream be used, then obviously 1000 - 27 or 973 lbs. of 3% milk is used to make up the 1000 lbs. of 4% milk. The amount of 3% milk used can also be found by applying the third rule, now that F has become a known quantity and S if the unknown to be found as shown in Fig. 5.



$S \times 1 = 27 \times 36$

$S = 972$ lbs. of 3% milk

Fig. 5

2. What butterfat content would result in a 2000 pound mixture by adding 20 pounds of 40% cream to 1980 pounds of 3% milk?

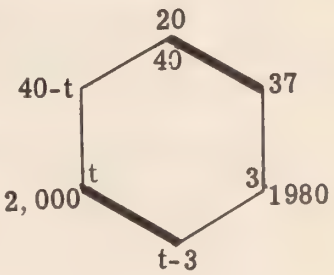


Fig. 6

This is represented on the hexagon in Fig. 6 when the above 3 rules are applied:

$20 \times 37 = 2000\ (t-3)$

$740 = 2000\ t - 6000$

$2000t = 6740$

$t = 3.37$, i.e., the resulting 2000 pounds of milk would be 3.37% butterfat.

3. How much water at 200° F. must be added to 35 gallons of water at 60° F. to produce water at 80° F. in a bath?

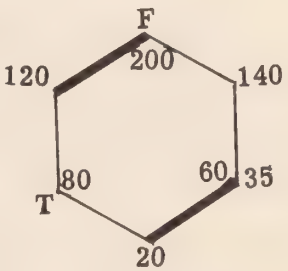


Fig. 7

This is solved by Fig. 7.

$120 \times F = 35 \times 20$

$120F = 700$

$F = \frac{700}{120} = 5.83$ gallons at 200° F. must be added.

4. How much 1% residual chlorine solution must be used to provide 2 ppm. residual chlorine to a reservoir containing 30,000 gallons of water? (The chlorine demand of the water is 0.5 ppm. Therefore the actual residual chlorine to be furnished in 2.5 ppm. It should be remembered that 1% = 10,000 ppm.)

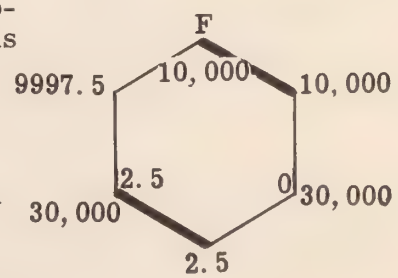


Fig. 8

In this case F = the unknown quantity of 1% (10,000 ppm.) residual chlorine solution to be added; S = the 30,000 gallons of water with no (0.0) residual chlorine, to be chlorinated; T = the resulting 30,000 gallons of water with 2.5 p.p.m. residual chlorine. The problem is solved by the hexagon of Fig. 8.

$10,000 \times F = 30,000 \times 2.5$

$10,000F = 75,000$

$F = \frac{75,000}{10,000} = 7.5$. gallons of 1% residual chlorine solution to be added.

Approximately the same result would be obtained if the 2 parallel lines represented by F x 9997.5 and 2.5 x 30,000 were used. The important consideration is that the provisions of the third rule be observed.

5. How much 4% and 0.2% solutions of a chemical should be mixed to obtain 1900 gallons of 0.3% solution of the chemical?

The problem is solved by the hexagon of Fig. 9.

$$3.8 \times F = 1900 \times 0.1$$
$$3.8F = 1900$$
$$F = 50 \text{ gallons of } 4.0\% \text{ solution to be used.}$$

Now that F is known, S can be calculated in either of two ways:

a) $1900 - 50 = 1850$ gals. of 0.2% solution to be used, or

b) $S \times 0.1 = 50 \times 3.7$
$0.1S = 185$
$S = 1850$ gals. of 0.2% solution.

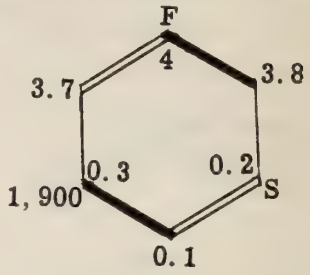


Fig. 9.

Properties of hexagon.

The hexagon has the following properties which should be used for a check after completion of each hexagon.

a. The products of the quantitative numerals at the outside corners of two parallel sides should be equal (or nearly so when approximate figures, avoiding decimals, have been used).

Let us take the figures of example 1, as shown in Fig. 10.

a) $36 \times 27 = 972 \times 1$
$972 = 972$

b) $27 \times 37 = 1000 \times 1$
$999 = 1000$

c) $37 \times 972 = 36 \times 1,000$
$35,964 = 36,000$

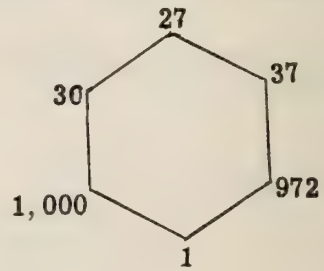


Fig. 10.

b. The product of the highest "quality number" inside the hexagon with the "quantity number" at the diametrically opposite corner, added to the product of the lowest "quality number" with the diametrically opposite "quantity number", must equal the product of the remaining "quality number" multiplied by its diametrically opposite "quantity number." See Fig. 11.

$$(40 \times 1) + (3 \times 36) = 4 \times 37$$
$$148 = 148$$

This last property means, that 1 gallon of 40% quality added to 36 gallons of 3% quality will produce 37 gallons mixture of 4% quality.

This is proven by the fact that:

$$1 \times 40\% + 36 \times 3\% = 37 \times 4\%$$
$$1 \times 0.40 + 36 \times 0.03 = 37 \times 0.04$$
$$0.40 + 1.08 = 1.48$$
$$1.48 = 1.48$$

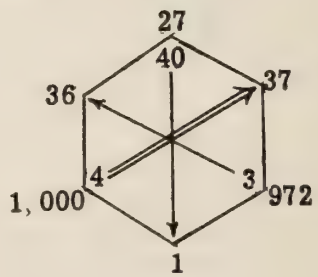


Fig. 11.

6. Determine the amount of chloride of lime containing 25% available chlorine that would have to be added to a filled reservoir 15 ft. high and 30 ft. in diameter to provide 2 ppm. chlorine residual, if the water be estimated to have a 10 ppm. chlorine demand.

$30 \times 30 = 900$ sq. ft.
$900 \times 0.7854 = 706.86$ sq. ft. = area of bottom of reservoir
$706.86 \times 15 = 10,602.9$ cubic ft. = capacity of the reservoir
$10,602.9 \times 62.4 = 661,621$ lbs. of water in reservoir
2 ppm. + 10 ppm. = 12 ppm. of chlorine actually needed
$661,621 : x :: 1,000,000 : 12$
$1,000,000\,x = 7,939,452$
$x = 7.94$ lbs. of chlorine

But the chloride of lime has only 25% available chlorine, therefore,

$$\frac{7.94}{25} \times 100 = \frac{794}{25} = 31.76 \text{ lbs. of chloride of lime needed}$$

7. Determine the retention period in a settling basin 15' x 40' x 10' if the flow through the basin be 240 gallons per minute.

15 x 40 x 10 = 6,000 cubic ft. = volume of basin
6,000 x 7.48 = 44,880 = volume in gallons
44,880 ÷ 240 = 187 minutes
or 3 hours and 7 minutes retention period.

8. A dug well with a 4 ft. inner diameter and a 4 inch wall is to be rebuilt with a 6 inch wall. The well is 10 ft. deep. The present well is to remain as the inside form of the new wall. How much cement, sand and gravel should be provided using a 1:2:3 mix?

The inside diameter of the new wall is 4 ft. 8 inches, or 4.66 ft.
" outside " " " " " " 5 " 8 " " 5.66 ft

Area of inner circle of new wall = $\frac{\pi d^2}{4} = \frac{3.1416 \times 21.72}{4} = 17.06$ sq. ft.

Area of outer circle of new wall = $\frac{\pi d^2}{4} = \frac{3.1416 \times 32.04}{4} = 25.16$ sq. ft.

25.16 - 17.06 = 8.10 sq. ft.
8.10 x 10 (depth) = 81.0 cu. ft. of well wall
6. ft. x 6 ft. x 4 inches = 12 cu. ft. for platform
81.0 + 12 = 93 cu. ft. total wet mix
93 x 3 = 139.5 cu. ft. dry mix
2

$\frac{139.5}{1+2+3} = \frac{139.5}{6} = 23.25$

Cement = 1 x 23.25 = 23.25 cu. ft. or sacks
Sand = 2 x 23.25 = 46.50 " "
Gravel = 3 x 23.25 = 69.75 " "

9. How many sacks of cement will be required for a driveway using 8 1/2 cubic yds of concrete? How many cu. ft. of sand will be required? How many cu. ft. of pebbles will be required? How many gallons of water?

The mix, in this case, should be 1:2 1/4:3 (See Table 119.) In the trial mix, about 5 gals. of water is used per sack of cement. If the sand be very wet use 1 gal. less water. If the sand be very dry, 1/2 gal. water more may be used per sack of cement.

1 cu. yd. of concrete requires:
6 1/4 sacks of cement (see Table 119.)
6 1/4 x 2 1/4 = 14 cu. ft. sand
6 1/4 x 3 = 19 " " gravel
6 1/4 x 5 = about 31 gals. water

8 1/2 cu. yds. of concrete requires:
8 1/2 x 6 1/4 = 53 sacks cement
8 1/2 x 14 = 119 cu. ft. sand
8 1/2 x 19 = 162 " " gravel
8 1/2 x 31 = 264 gals. water

10. What would be the total volume in cu. yds. of concrete that could be mixed with 23 sacks of cement? The concrete is to be used for heavy foundation work.

The mix should be 1:2 3/4:4 (See Table 119.) In the trial mix, no more than 5 1/2 gals. water should be used per sack of cement (See Table 118.)

1 cu. yd. concrete requires:
5 sacks of cement (see Table 119.)
5 x 2 3/4 = 14 cu. ft. of sand
5 x 4 = 20 cu. ft. of gravel.

If 1 cu. yd. of concrete requires 5 sacks of cement, then 23 sacks could make up $\frac{23}{5}$ = 4.6 cu. yds. concrete.

11. How many square feet of sidewalk can be made per sack of cement if the slabs be made 5 inches thick?

The mix should be 1:2 1/4:3
1 cu. yd. of concrete requires:
6 1/4 sacks cement
14 cu. ft. sand
19 " " gravel
1 cu. yd. concrete = 27 cu. ft.
If 6 1/4 sacks cement make 27 cu. ft. concrete,
Then 1 sack " makes 27 ÷ 6 1/4 = 4.32 cu. ft.
5 inches = $\frac{5}{12}$ ft.

$4.32 \div \frac{5}{12}$ = 10.37 square feet of slab per sack of cement

12. A tank wagon holds 20 barrels of water. Each barrel holds 31 1/2 gals. How many loads will be required to furnish mixing water for 108 cu. yds. of concrete if 5 gals. of water be required per sack of cement, and the mix required is 1:2 1/4: 2 1/2.

1 cu. yd. of concrete requires 6 1/2 sacks of cement.
108 cu. yds. of concrete requires 108 x 6 1/2 = 702 sacks of cement.
Each sack of cement requires 5 gals. water.
Therefore 702 sacks cement requires 702 x 5 = 3,510 gals. of water.
Each wagon load carries 20 x 31 1/2 = 630 gals. water.
Therefore 3,510 ÷ 630 = 5.57 loads.

13. It is desired to find out the quantity of water flow in a small stream. A section of the stream should be selected that is reasonably straight with a bottom contour that is as uniform as possible. The cross-section of the stream can be figured by taking measurement of depth of water at various points across the stream. The average depth and width of the stream is estimated and the cross-section determined in square feet. The velocity of flow is measured by observing the speed of travel of a chip floating down the middle of the stream. The velocity should be measured in feet per second. The surface velocity is more rapid than the average velocity and it has been determined that 4/5 the surface velocity is equal to the average velocity.

Therefore, the stream flow in cubic feet per second is equal to the cross-sectional area in square feet times the surface velocity in feet per second times 4/5.

Example: Stream with average depth of 9 inches and approximate width of 5 feet. Surface velocity is 3 feet per second.

Cross-sectional area = $\frac{9}{12}$ x 3 = $\frac{45}{12}$ = $\frac{15}{4}$ = 3.75 sq. ft.

$3.75 \times 3 \times \frac{4}{5} = 11.25 \times \frac{4}{5}$ = 9 cu. ft./sec.

9 cu. ft./sec. x 7.5 = 67.5 gallons per sec.
67.5 x 60 = 4,050 gallons per minute.

14. The B.O.D. (Biochemical Oxygen Demand) of a sewage is 120 ppm. The stream into which it will be discharged has a dissolved oxygen content of 15 ppm. What percentage of purification will the sewage have to undergo before the effluent may be allowed to empty into the stream if the dissolved oxygen in the stream is not to fall below 6 ppm. Assume the sewage is discharged at the rate of 500 gallons per minute and the stream flow is 2500 gallons per minute (G.P.M.) The total stream flow below the sewage outfall is 3,000 G.P.M. of which 1/6 is sewage and 5/6 is dilution water.

The stream will furnish 5 parts and the sewage one part of the total flow of 6 parts. The

desired residual oxygen is 6 ppm. The stream can furnish 5 (15-6) = 45 ppm. of oxygen. The sewage will need 120+6 = 126 ppm. of oxygen in order to neutralize the demand of the sewage and also furnish a residual of 6 ppm. of oxygen. The amount of oxygen that must be furnished by the treatment plant is, then, 126 - 45 = 81 ppm. Since removing that much oxygen demand from the sewage would give the same result as furnishing that much oxygen to the stream, 81 parts of oxygen demand would have to be removed from the total sewage demand of 120 parts, which means the plant would have to give $\frac{81}{120} \times 100 = 67.5\%$ purification.

15. Determine the retention period in a settling basin 10 feet wide, 30 feet long, and 8 feet deep if the flow through the basin be 250 gallons per minute.

The capacity of the basin is 10 x 30 x 8 = 2400 cubic feet.

One cubic foot is equivalent to 7.48 gallons.

Therefore the capacity of the basin in gallons is 2400 x 7.48 = 17,952 gallons.

If the flow through the basin be 250 gallons per minute, the retension time would be 17,952 ÷ 250 = 71.4 minutes.

16. Compute the saving in cost of soap per family of five per year due to installation of a softening plant under the following conditions:

a) The quantity of water softened by soap per capita per day is 1.2 gallons.

b) The quantity of soap required to reduce the hardness of 1,000 gallons of water one part per million is 0.2 pounds.

c) The original hardness of the water is 225 ppm.

d) The hardness is softened at the municipal plant to 50 ppm.

e) The average price of soap is 23¢ per pound.

1.2 gals. x 5 x 365 = 2,190 gallons of water used each year by the family.

If 0.2 pounds of soap reduces the hardness of 1,000 gals. by 1.0 ppm., then it would take $\frac{2,190}{1,000} \times 0.2 = 0.438$ pounds of soap to reduce the hardness of 2,190 gals. by 1.0 ppm.

But the plant reduces the hardness from 225 ppm. to 50 ppm. or 175 ppm.

Therefore the amount of money saved annually is 0.438 x 175 x 0.23 = $17.63

17. A town pumps 864,000 gallons per day from a lake for its water treatment plant. A change to well water is desired. The town has acquired an artesian well, located 2,000 yards from the pump house, with a flow of 800 gallons per minute at a pressure of 98 pounds per square inch.

a) What is the size of the pipe line needed for the connection?

b) If a pressure of 60 pounds is to be maintained in the mains, and the well can be connected to the system at a distance of 1,200 yards from the well, what is the pipe size needed in this case? What method would be the cheaper?

In order to solve this problem certain basic formulae must be known. The formulae will first be explained and then the problem worked.

a. $Q = A \times V$ — The quantity of flow (Q) of water, in cubic feet per second, = the cross-section area (A) of the pipe, in square feet, times the velocity (V) of the water, in feet per second. The cross-section area of a pipe = $\frac{\pi d^2}{4}$ or 3.1416 x diameter squared ÷ 4.

b. $V = \frac{Q}{A}$ — The velocity of the water, in feet per second, = the quantity of flow of water, in cubic feet per second, divided by the cross-section area of the pipe, in square feet.

c. $H = \frac{V^2}{2g} = \frac{V^2}{64.4}$ — The velocity head (H) causing the velocity = the velocity squared (V^2) divided by two times g. The g stands for the acceleration of gravity and has a value of about 32.2 at sea level.

d. 1. $Q_{g.p.m.} = Q_{c.f.s.} \times 450$ — The quantity of flow of water, in gallons per minute (g. p. m.) = the quantity of flow, in cubic feet per second (c. f. s.) times 450. The 450 is derived by multiplying 60 seconds by 7. 5 (gallons per cubic feet).

2. $Q_{g.p.h.} = Q_{c.f.s.} \times 27,000$ — The quantity of flow, in gallons per hour (g. p. h.) = the quantity of flow, in cubic feet per second, times 27, 000. The 27, 000 is derived by multiplying 60 seconds x 60 minutes x 7. 5.

e. 1. $h_F = \frac{V^2}{2g}\left(1.5 + f\frac{L}{D}\right)$ — The loss of head (h_F) in pipes less than 100 feet long = the velocity head (formula c) times 1. 5 plus the coefficient of friction (f) multiplied by the length of the pipe (L), in feet, divided by the diameter of the pipe (D), in feet.

$f = 0.025$ — This is the average coefficient of friction of pipes.

2. $h_F = \frac{V^2}{2g}\left(f\frac{L}{D}\right)$ — The loss of head in pipes longer than 100 feet.

f. 1 lb./sq. in. = 2. 31 ft. of water — This means that a column of water in a pipe, 2. 31 feet long and having a cross-section area of one square inch has a pressure of 1 pound.

Solution of Problem.

a) The average consumption of water is $\frac{864,000}{24} = 36,000$ g. p. h.

The well can supply 800 x 60 = 48, 000 g. p. h., if the pipe size be correctly chosen.

Using formula d. 2.,

$$36,000 \text{ g.p.h.} = Q_{c.f.s.} \times 27,000$$

$$Q_{c.f.s.} = \frac{36,000}{27,000} = 1.333 \text{ cubic feet per second.}$$

Using formula b, and assuming a pipe diameter of 4" or 1/3 ft.,

$$V = \frac{1.333}{\frac{3.1416 \times (1/3)^2}{4}} = \frac{1.333}{0.0873} = 15.3 \text{ per second}$$

$$\text{Loss of head or } h_F = \frac{(15.3)^2}{64.4} \times 0.025 \frac{(3 \times 2000)}{(1/3)}$$

$$h_F = \frac{234}{64.4} \times 0.025 \frac{(6000)}{(1/3)}$$

$$h_F = 3.63 \times 450 = 1,634 \text{ feet loss of head with 4" pipe.}$$

Using formula f,

98 lbs./sq. in. x 2. 31 = 226 feet head (the maximum allowable loss of head). Since the maximum allowable loss of head is 226 ft., and the 4" pipe produces a loss of head of 1, 634 feet, the 4" pipe is too small.

Assuming a 6" pipe,

$$V = \frac{1.333}{\frac{3.1416 \times (1/2)^2}{4}} = \frac{1.333}{0.1963} = 6.79 \text{ ft. per second.}$$

$$h_F = \frac{(6.79)^2}{64.4} \times 0.025 \frac{(6000)}{(1/2)} = \frac{46.1}{64.4} \times 300 = 215 \text{ feet loss of head with 6" pipe.}$$

Since the maximum allowable loss of head is 226 ft. and 6" pipe produces a loss of head of only 215 ft., the 6" pipe will be satisfactory.

b) If a pressure of 60 pounds is to be maintained in the mains, the allowable loss of head is 98 - 60 = 38 pounds.

$38 \times 2.31 = 87.8$ feet (maximum allowable loss of head).

Assuming a 6" pipe,

$V = 6.79$ ft./sec., $L = 3,600$ ft. instead of 6000 ft.

$$h_F = \frac{(6.79)^2}{64.4} \times 0.025 \frac{(3600)}{(1/2)} = 128.8 \text{ ft. loss of head with 6" pipe.}$$

Since the maximum allowable loss of head is 87.8, and the 6" pipe produces a loss of head of 128.8 ft., the 6" pipe is too small.

Assuming an 8" pipe,

$$V = \frac{1.333}{\frac{3.1416 \times (2/3)^2}{4}} = \frac{1.333}{0.349} = 3.82 \text{ ft. per sec.}$$

$$\text{Loss of head} = \frac{(3.82)^2}{64.4} = 0.025 \frac{(3600)}{(2/3)} = \frac{14.6}{64.4} \times 135 = 30.6 \text{ ft.}$$

Since the maximum allowable loss of head is 87.8 and the 8" pipe produces a loss of head of only 30.6 ft., then the 8" pipe is satisfactory.

18. A raw sewage entering an Imhoff tank contains a volume of 5.9 milliliters of setteable solids per liter of sewage. The effluent of the Imhoff tank contains 0.3 milliliters volume of settleable solids per liter of sewage. Determine the percent of settleable solids removed.

$5.9 - 0.3 = 5.6$

$$\frac{5.6}{5.9} = 5.9 \div 5.6 = 94.9\% \text{ of settleable solids removed.}$$

19. Assume a minimum dissolved oxygen in a stream of 8.0 ppm. and a residual dissolved oxygen content of 5.0 ppm. to be left in the stream. The stream flow is estimated at about 30,000 gallons per second. Calculate the amount of oxygen in pounds per day available in the stream for oxidizing sewage.

The number of seconds in one day = $60 \times 60 \times 24 = 86,400$ seconds.

$86,400 \times 30,000 = 2,592,000,000$ gals. per day of stream flow.

For every million gals. of water, 3 gals. of oxygen is available for use.

Therefore $\frac{2,592,000,000}{1,000,000} \times 3 = 7,776$ gals. of oxygen available for use.

$7,776 \times 8.34 = 64,851.84$ pounds of oxygen available for use each day.

20. Bathing Loads (See Chapter on Swimming Pools)

The calculations for bathing loads should be based on the following rules:

1. In the area of non-swimmers, i.e., the shallow area, the average space allowed for each non-swimmer should be approximately 1/2 that allowed for each swimmer in the deep water.
2. In the deep water, exclusive of area around diving board, an area of 27 square feet should be provided for each swimmer.
3. In the water around the diving area for a radius of 10 feet around the extremity of the diving board, no more than 3 persons should be allowed, and no more than 9 persons on shore or on the diving platform awaiting their turn to dive.

Therefore 3 separate calculations should be made for each pool which has a shallow area, a deep area, and a diving board.

Let us assume that on the basis of the sum of the 3 calculations, 211 persons are allowed in a pool of 180,000 gallons capacity where the water is changed completely every day. What would be the maximum permissible bathing loads in this pool if it were:

a) A fill-and-draw pool in which the water is changed weekly.
b) A flow-through pool in which the daily addition of fresh water is 75,000 gallons.
c) A recirculation pool in which the water is turned over twice daily.

a. In the fill-and-draw pool in which the water is changed weekly, the daily load allowed would be:

$$\frac{211}{7} = 30 \text{ persons}$$

b. In the flow-through pool in which the daily addition of fresh water is 75,000 gallons, the water is changed in the pool every 2.5 days, i.e., 180,000 ÷ 75,000 = approximately 2.5, therefore the daily load should be $\frac{211}{2.5}$ = 85 persons.

c. In the recirculation pool in which the water is turned over twice daily, the load should be 211 x 2 = 422 persons.

The following problems on refrigeration should be worked after studying the chapter on Fundamentals of Refrigeration.

In these problems, it is assumed that there are no heat losses to the equipment and the atmosphere.

21. How much refrigeration would be available by the melting of 1000 pounds of ice (a) of 32° F? (b) of 20° F?

(Note: It requires 144 B.t.u. to melt 1 pound of ice at 32° F., and about 0.5 B.t.u. per degree to change the temperature of ice below the melting point.)

(a) Since one pound of ice would extract a heat of 144 B.t.u. by melting, 1000 pounds will extract 144,000 B.t.u.

(b) Before the ice melts, its temperature has to be raised 12° F. for which is needed 12 x 0.5 = 6 B.t.u. per pound. For 1000 lbs., therefore, the additional refrigeration is 1000 x 6 = 6,000 B.t.u. and the total refrigeration 144,000 + 6,000 = 150,000 B.t.u.

22. How much refrigeration would be available with 807.50 pounds of ice and 142.50 pounds of salt, both ingredients being mixed at a temperature of 32° F., until all ice be melted?

(Note: 15% salt mixture has 133 B.t.u. available refrigeration per pound.)

142.50 pounds of salt added to 807.50 pounds of ice makes 950 pounds of mixture. The percentage of salt is $\frac{142.50}{950}$ x 100 = 15%.

Each pound of this mixture has a refrigerating capacity of 133 B.t.u.
The total refrigeration is therefore 950 x 133 = 126,350 B.t.u.

23. 300 pounds of milk are placed in a vat with chipped ice of 32° F. How many pounds of ice will have melted when the milk is cooled from 90° F. to 32° F?

(Note: Milk has an average specific heat of 0.93)

300 x (90 -32) x 0.93 B.t.u. = 300 x 58 x 0.93 = 16,182 B.t.u. needed,
or $\frac{16,182}{144}$ = 112.3 lbs. of ice melted.

24. How many pounds of ice will be required to cool 300 pounds of milk from 90° to 40° F?

(a) Under the condition of problem 23.

(b) When all the ice provided is melted and end temperatures of mix and milk are the same (specific heat of milk is 0.93)

(a) B.t.u. to be extracted:

$$300\ (90 - 40) \times 0.93 = 13,590 \text{ B.t.u.}$$

$$\frac{13,950}{144} = 96.2 \text{ lbs.}$$

(b) Each pound of ice, after becoming a pound of water and extracting 144 B.t.u., is heated to 40° F., extracting (40 -32) = 8 B.t.u. more from the milk. The total B.t.u. per original pound of ice is therefore 144 + 8 = 152 B.t.u. and the amount of ice needed is

$$\frac{13,950}{152} = 91.8 \text{ lbs.}$$

25. How many gallons of milk at 70° F. could be cooled to 32° F. with 150 pounds of salt at 65° F. and 850 pounds of ice at 32° F.?

(Note: 1 gallon of milk weighs about 8.6 pounds. The specific heat of salt = 0.214)

To lower the temperature of 1 lb. of milk from 70° F. to 32° F. it is necessary to extract

$$(70 - 32) \times 0.93 = 35.34 \text{ B.t.u.}$$

And to lower the temperature of 1 gallon from 70° F. to 32° F.

$$8.6 \times 35.34 = 303.9 \text{ B.t.u.}$$

To reduce the temperature of 150 lbs. of salt from 65° F. to 32° F.

$$(65 - 32) \times 150 \times 0.214 = 1059.3 \text{ B.t.u. to be extracted.}$$

150 pounds of salt plus 850 pounds of ice form 1000 lbs. of 15% mix of which the refrigeration capacity is 133 B.t.u. per pound, or a gross total of 133,000 B.t.u. However, 1059.3 B.t.u. have been used to cool the salt, giving a net total of 131,940.7 B.t.u.

This will provide a refrigeration of

$$\frac{131,940.7}{303.9} = 434.1 \text{ gallons of milk.}$$

Note: The above amount represents the refrigeration possible until all ice is melted. The brine will then have a temperature of about 12° F. At an average specific heat of 0.838, the brine rising to a temperature of 32° F. will extract from the milk, per pound, (32 - 12) x 0.838 = 16.76 B.t.u., or for 1000 pounds, 16,760 B.t.u. The more correct amount of gallons of milk, therefore, would be found by adding $\frac{16,760}{303.9} = 55.1$ gallons to 434.1 gal. to give a total of 489.2 gal.

26. How many quarts of milk in Problem 21 could be reduced from 70° F. to 40° F?

One quart of milk weighs $\frac{8.6}{4} = 2.15$ lbs.

To reduce one quart of milk from 70° F. to 40° F.:

$$(70 - 40) \times 2.15 \times 0.93 = 5.998 \text{ or about 6 B.t.u. should be extracted.}$$

We have seen in Problem 21, that 131,940 B.t.u. be the amount of refrigeration available until all mixture has become brine at a temperature of 12° F. Therefore, raising the brine temperature to 40° F., addition refrigeration will be available:

$$1000 \times (40 - 12) \times 0.84 = 23,520 \text{ B.t.u.}$$

Total refrigeration $131,940 + 23,520 = 157,460$ B.t.u.

This will cool $\frac{157,460}{6}$ = about 26,243 quarts of milk from 70° F. to 40° F.

27. If 100 gallons of milk of 82° F. be placed in a cooling vat holding 2000 gallons of well water of 48° F. and held until temperature of milk and water be the same, what will this temperature be?

Let us call the final temperature T. To reach this temperature, the water has been absorbing heat from the milk. The total amount of the heat absorbed by the water is equal to the total amount given off by the milk, as it is assumed that there are no heat losses to equipment or atmosphere. This temperature will therefore be higher than 48° F. and lower than 82° F.

Weight of milk: $100 \times 8.6 = 860$ lbs. Weight of water: $2000 \times 8.34 = 16,680$ lbs.

$$16,680 (T - 48) = 860 (82 - T) \times 0.93 =$$

$$16,680T - 800,640 = 65,600 - 800T.$$

$$17,480T = 866,240$$

$$T = \frac{866,240}{17,480} = 29.56° \text{ F.}$$

Check:

$$16,680 \times (49.56 - 48 = 800 (82 - 49.56)$$

$$16,680 \times 1.56 = 800 \times 32.44$$

$$25,710 = 24,952$$

(The little difference is caused by the fact that T was calculated only to 2 decimals.)

28. Suppose that 142.50 pounds of salt in Problem 18 has a temperature of 55° F., and the ice a temperature of 32° F., and both ingredients are mixed in 30 gallons of water of which the temperature is 60° F. What would be the amount of B.t.u. available for refrigeration until all ice be melted?

(Note: Salt has a specific heat of 0.214
One gallon of water weighs 8.34 pounds.
Temperature of 15% mixture = 12° F.)

To bring all ingredients to the temperature at 32° F., heat has to be extracted from the mixture itself by the melting action of the ice. This is therefore a refrigeration loss, which is calculated as follows:

Cooling of salt: (55 -32) x 0. 214 = 23 x 0. 214 = 4. 922 B. t. u. per lb.
For 142. 50 lbs. : 142. 50 x 4. 922 = 701. 4 B. t. u.
Cooling of water: 30 gallons = 30 x 8. 34 = 250. 2 lbs.
For (60 - 32) = 28 degrees: 250. 2 x 28 = 7005. 6 B. t. u.
Total loss of refrigeration to 32° F. = 7005. 6 + 701. 4 = 7, 707 B. t. u.

Now if there had been no water added, the mixture would have been finally melted at 12° F. But 250 lbs. of water have been added which has to be cooled, and a refrigeration loss occurs from 32° F. downward until the final temperature T be reached. Then: Heat absorbed by mixture = heat given off by water, or

$$950 \times (T - 12) = 250 (32 - T) = 3950 \text{ B. t. u.}$$
$$950\ T - 11,400 = 8000 - 250\ T$$
$$1200\ T = 19,400$$
$$T = 16.2^{\circ} \text{ F.}$$

Total final loss of refrigeration = 7, 707 + 3, 950 = 11, 657 B. t. u.
and total refrigeration: 126, 350 (Problem 18)
- 11, 657
114, 693 B. t. u.

Hot Water for Restaurant Use

Basic Data Needed to Work Problems

1. The longer the wash-up period, the more one must depend on the heater capacity as compared to the storage tank capacity.
2. 70% of the total capacity of a hot water storage tank can be withdrawn without experiencing a temperature drop of more than 3° F.
3. Amount of hot water needed for different classes of food service: Average meal service required 1. 8 gals. per patron per meal; average school lunchroom meal requires 1. 4 gals. per patron per meal; banquet meal service requires 2. 2 gals. per patron per meal; hamburger counter service requires 1. 3 gals. per patron per meal.
4. Hot water usage is distributed as follows: 28% for food preparation period, 55% for dishwashing period, 17% for the clean-up period.
5. Gas as used in a gas heater has 80% efficiency as a fuel, and electricity has 100% efficiency. Underneath gas burners are about 60% efficient.
6. 1 B. T. U. raises 1 lb. of water 1° F. ; 1 gal. water weighs 8 1/3 lbs. ; therefore 8 1/3 B. T. U. raises 1 gal. water 1° F.
7. Quantity of hot water needed:
   a. 9 gals. per minute is a standard optimum for single tank dishwasher (sanitizing rinse).
   b. 1/3 gal. per 100 sq. inches of dish rack for a single tank dishwasher:
      (1) 1 1/2 gals. in 10 seconds for the normal 20" x 20" rack
      (2) 1 gal. in 10 seconds for the normal 16" x 16" rack

Field Test for Determining Hot Water Quantity - Single tank machine (Sanitizing rinse)

1. Empty wash tank
2. Determine volume of tank:

   Capacity in gallons (rectangular) = $\dfrac{\text{length (inches)} \times \text{width (inches)} \times \text{height (inches)}}{231}$ = gals.

   Capacity in gallons (circular) = Diameter^2 (inches) x length (feet) x 0. 0408 = gals.
3. Open rinse valve and start timing.
4. Close rinse valve when tank is full and stop timing.
5. Compute volume rate of rinse (gallons/minute is desirable).

Working Problems

1. Heater capacity - storage capacity

A 180 gal. per hour instantaneous heater and a 300 gal. hot water storage tank are available. What are the total gallons per hour of hot water delivery available for a 1-hour wash-

up period, and a 2-hour wash-up period?

a) Water available in 1-hour washing period = (Heater capacity)+ (Hot water storage capacity) x (70% efficiency) = 180 gph+ 300 (0.70) gph = 180+210 gph = 390 gal. per hour

b) Water available in 2 hour washing period = (Heater capacity)+ (Hot water storage capacity)x (70% efficiency) / 2 = 180 gph + 300 (0.70) gph / 2 = 285 gal. per hour

2. Handwashing - Emersion

A restaurant uses hot water emersion and sanitizes 15 baskets per hour. Each basket has 20 lbs. of utensils. The rinsing compartment uses 100° F. water, so we must raise the dishes 70° F. in the sanitizing compartment. What are (a) the gas burner capacity, and (b) the electric burner capacity needed for the sanitizing sink.

Gas Burner Capacity

a. Weight of dishes sanitized per hour = 15 x 20 pounds = 300 lbs.

b. This is equivalent to heating 120% as much water because of the greater difficulty in heating dish material:

1.20 x 300 = 360 lbs. of water per hour.

c. B.T.U. required for the 70° F. rise in temperature is:

360 x 70 = 25,200 B.T.U. per hour

d. Radiation loss is 19%. The B.T.U. increase therefore is

25,200+0.19(25,200) = 25,200+4800 = 30,000 B.T.U. per hour

e. Underneath burners are only 60% efficient, so with the gas burner we need:

30,000 : 60 :: x : 100

60x = 3,000,000

x = 50,000 B.T.U. per hour

Note: Side arm heaters would be more efficient, in all probability approaching 80%.

Electric Burner Capacity

a. We need 30,000 B.T.U. per hour

b. Electric burners are 100% efficient

c. 1 kilowatt hr. = 3412 B.T.U.

d. 30,000 B.T.U. ÷ 3412 B.T.U. = 9 kw per hour

3. Dishwashing Machine

A gas heater whose plate reads 190,000 B.T.U. per hour is installed in a restaurant which serves 500 patrons an average type meal. What size hot water tank is needed for the dishwashing machine if the washing period takes 1 hour, 2 hours?

a. Gas heater = 80% efficiency, therefore, the effective B.T.U. per hour = 0.80 x 190,000 = 152,000 B.T.U. per hour

b. Since 8 1/3 B.T.U. raise 1 gal. water 1° F., and water must be raised to 100° F., the heater capacity is: $\frac{152,000}{8\ 1/3 \times 100}$ = 180 gal. per hour

c. The dishwashing period requires 55% of the hot water, therefore, if 1.8 gal. per patron per average meal service are required, then the dishwashing period will require:

1.8 x 0.55 = 1 gal. per patron per meal

d. Gallons of water required for 500 patrons at 1 gal. per patron per meal = 500 gal. per hour.

e. Heater provides 180 gal. per hour, therefore, we need a hot water tank of 500-180 = 320 gals.

f. The tank is only 70% efficient, therefore its size should be:

320 : 70 :: x : 100

70x = 32,000

x = 460 gal. tank for 1 hour washing period

g. For a 2 hour washing period, the heater will provide 2 x 180 gph = 360 gal.

h. Since 500 gals. are needed, the tank must be able to store 500 - 360 = 140 gals. hot water.

i. Assuming a 70% efficiency tank, we actually need:

140 : 70 : : x : 100

70 x = 14,000

x = 200 gallon tank for 2 hour washing period

Weights, Measures, and Useful Memoranda

Surface Measure

Customary Units

12 inches	=	1 foot
3 feet	=	1 yard
5 1/2 yards	=	1 rod
40 rods	=	1 furlong
8 furlongs	=	1 mile
3 miles	=	1 league

144 square inches	=	1 square foot
9 square feet	=	1 square yard
30. 25 square yards	=	1 square rod
160 square rods	=	1 acre
640 acres	=	1 square mile

Metric

10 millimeters (mm)	=	1 centimeter (cm.)
10 centimeters	=	1 decimeter (dcm.)
10 decimeters	=	1 meter (m)
10 meters	=	1 dekameter (dkm.)
10 dekameters	=	1 hektometer (hkm.)
10 hektometers	=	1 kilometer (km.)

100 sq. millimeters	=	1 sq. centimeter
100 sq. centimeters	=	1 sq. decimeter
100 sq. decimeters	=	1 sq. meter
100 sq. meters	=	1 sq. dekameter
100 sq. dekameters	=	1 sq. hektometer

Surveyor's Linear Measure

1 link	=	7. 92 inches
25 links	=	1. 0 rod
4 rods	=	1 chain
100 links	=	1. 0 chain
1 chain	=	66. 0 feet
80 chains	=	1. 0 mile

Surveyor's Square Measure

625 sq. links	=	1 sq. rod
16 sq. rods	=	1 sq. chain
10 sq. chains	=	1 acre
160 sq. rods	=	1 acre
640 acres	=	1 sq. mile
1 sq. mile	=	6, 400 sq. chains
1 sq. chain	=	484 sq. yards
1 sq. chain	=	10, 000 sq. links

Table of Equivalents of Surface Measures

1 inch	=	25. 40 millimeters
1 inch	=	2. 5399 centimeters
1 foot	=	30. 479 centimeters
1 yard	=	0. 914 meter
1 mile	=	1. 609 kilometers

1 micron	=	0. 001 millimeter
1 millimeter	=	0. 0394 inch
1 centimeter	=	0. 3937 inch
1 meter	=	39. 3708 inches
1 kilometer	=	0. 6214 mile

1 sq. millimeter	=	0. 00155 sq. inch
1 sq. centimeter	=	0. 1550 sq. inch
1 sq. decimeter	=	0. 1076 sq. foot
1 sq. meter	=	10. 764 sq. feet
1 sq. meter	=	1. 196 sq. yards
1 hektar	=	2. 47 acres
1 sq. kilometer	=	0. 386 sq. mile

1 sq. inch	=	6. 452 sq. centimeters
1 sq. foot	=	9. 2903 sq. decimeters
1 sq. yard	=	0. 8361 sq. meter
1 acre	=	0. 4047 hecktar
1 sq. mile	=	2. 59 sq. kilometers

Volume Measure

1728 cubic inches	=	1 cubic foot
27 cubic feet	=	1 cubic yard
2, 150. 5 cubic inches	=	1 bushel
231 cubic inches	=	1 gallon
1 cubic foot	=	4/5 bushel
128 cubic feet	=	1 cord

1000 cubic millimeters	=	1 cubic centimeter
1000 cubic centimeters	=	1 cubic decimeter
1000 cubic decimeters	=	1 cubic meter
1000 cubic meters	=	1 cubic dekameter
1000 cubic dekameters	=	1 cubic hektometer
1000 cubic hektometers	=	1 cubic kilometer

1 cubic inch	=	16.387 cubic centimeters			
1 minim	=	0.061 cubic centimeters			
1 fluid dram	=	3.697 cubic centimeters	1 cubic centimeter	=	0.061 cubic inch 16.231 minims fluid 0.2705 fluid dram 0.034 fluid ounce
1 fluid ounce	=	29.573 cubic centimeters			
1 gill	=	118.3 cubic centimeters			
1 fluid pint	=	473.17 cubic centimeters			
1 fluid quart	=	946.33 cubic centimeters			
1 fluid gallon	=	3.785 liters	1 liter	=	33.81 fluid ounces 2.1134 fluid pints 1.0567 fluid quarts 0.2642 fluid gallon 1.8162 dry pint 0.9081 dry quart
1 dry pint	=	550.6 cubic centimeters			
1 dry quart	=	1.101 liters			
1 dry gallon	=	4.405 liters			
1 peck	=	8.81 liters			
1 bushel	=	35.24 liters			

Weight Measure

Apothecary

20 grains	=	1 scruple
3 scruples	=	1 dram
8 drams	=	1 ounce
12 ounces	=	1 pound

Avoirdupois

27.34	grains	=	1 dram
16	drams	=	1 ounce
16	ounces	=	1 pound
25	pounds	=	1 quarter
4	quarters	=	1 hundred weight
2000	pounds	=	1 short ton
2240	pounds	=	1 long ton

Metric

10 milligrams	=	1 centigram
10 centigrams	=	1 decigram
10 decigrams	=	1 gram
10 grams	=	1 dekagram
10 dekagrams	=	1 hektogram
10 hektograms	=	1 kilogram
10 kilograms	=	1 myriagram
10 myriagrams	=	1 quintal
10 quintals	=	1 tonne

Equivalent Weights

1 milligram	=	0.0154 grain
1 gram	=	15.432 grain
1 kilogram	=	2.2046 pounds
1 kilogram	=	32.151 ounces (apoth)
1 kilogram	=	35.274 ounces (avoir)
1 metric tonne	=	1.1023 short ton

1 gamma	=	0.001 milligram
1 grain	=	64.799 milligram
1 gram	=	0.03527 ounces
1 dram (avoir)	=	1.772 grams
1 dram (avoir)	=	3.888 grams
1 ounce (avoir)	=	28.35 grams
1 ounce (apoth)	=	31.103 grams
1 ounce (apoth)	=	480 grains
1 ounce (avoir)	=	437.5 grains
1 pound (avoir)	=	0.4536 kilograms
1 pound (apoth)	=	0.3732 kilograms

Circular Measure

60 seconds (")	=	1 minute (')
60 minutes	=	1 degree (o)
90 degrees	=	1 right angle
360 degrees	=	1 circle
1/4 circle	=	1 quadrant
1/6 circle	=	1 sextant

Water

1 gallon of water weighs 8. 34 pounds.
1 cubic foot of water equals 7. 48 gallons.
1 cubic foot of water weighs 62. 4 pounds.
"Head" of water is the vertical height of the water surface above any given point. This is always expressed in feet.
Under a given head, water presses equally in all directions (Pascal's Law).
Water is the standard for specific gravity of liquids and solids. Specific gravity of water is 1. 0.
Boiling point is 212° F. or 100° C.
Freezing point is 32° F. or 0° C.
Latent heat of vaporization is 966 British thermal units or 536. 6 calories at 100° C.
Latent heat of fusion is 144 British thermal units or 80 calories at 0° C.
Expansion from point of maximum density (at 4° C.) to boiling point is 1/23 of bulk.
One cubic inch of water evaporated under an atmosphere of pressure is converted into approximately one cubic foot of steam, or an approximate increase of 1600 times of volume.
Head of water x 0. 433 equals pounds per square inch. 0. 433 equals weight (in pounds) of a column of water 1 square inch in section and 12 inches in height.
Head of water x 62. 4 equals pounds per square foot.
Head of water x 0. 34 equals pounds per circular inch.
0. 041 equals gallons contained in 1 foot of 1 inch pipe.
Diameter of pipe or cylinder in inches squared x 0. 041 equals gallons per foot run.
The relative discharging powers of pipes are as the square root of the fifth power of their diameters:

$$\text{Discharge of water through pipes} = G = \sqrt{\frac{(3d)^5 \times H}{L}}$$

G = No. gallons discharged per minute
d = Diameter of pipe in inches
H = Head of water in feet
L = Length of pipe in yards

The relative capacities of pipes are as the square of their diameter.
Hydraulic Mean Depth is the sectional area of flow divided by the wetted perimeter.
Hydraulic Gradient varies with diameter, fall, and volume of flow. It may be said to be the height to which water would rise under its own head at various points along a line of pipe running full bore.
Hydraulic Mean Gradient is the total length (measured horizontally) divided by the total fall.

Heat

1° C. is equal to 1. 8° F.
To convert Centigrade to Fahrenheit, multiply the centigrade reading by 9/5 and add 32.
To convert Fahrenheit to Centigrade, subtract 32 from the Fahrenheit reading and multiply by 5/9.
Specific Heat is the amount of heat necessary to raise one gram of a substance 1° C.
Latent Heat is the amount of heat given out or absorbed by a substance in the act of changing from one state to another e. g. water to ice.
British Thermal Unit (B. t. u.) is the amount of heat required to raise 1 pound of water at the point of maximum density (39. 2° F.) through 1° F; or more correctly 1/180 of the heat required to raise 1 pound of water from 32° F. to 212° F.
Calorie is the amount of heat required to raise 1 kilogram of water through 1° C. ; or more correctly from 0° C. to 1° C. (This is the large calorie.)
Calorie is the amount of heat required to raise 1 gram of water through 1° C; or more correctly from 15° C. to 16° C. (This is the small calorie.)
Therm is 100, 000 British thermal units.

Approximate Weight and Measure Equivalents

Grains	Grams	Grams	Grains	Avoirdupois Pounds	Kilograms	Avoirdupois Ounces	Grams
15.43	1.0	1	15.432	1	0.454	0.035	1
5	.324	2	30.86	2	0.907	.071	2
2 1/2	.162	3	46.29	3	1.361	.106	3
1	.065	4	61.72	4	1.814	.141	4
7/8	.0567	5	77.16	5	2.268	.176	5
3/4	.0486	6	92.59	6	2.722	.212	6
1/2	.0324	7	108.0	7	3.175	.247	7
3/8	.0243	8	123.5	8	3.629	.282	8
1/4	.0162	9	138.9	9	4.082	.317	9
1/8	.0081	10	154.3	2.205	1	1	28.350
1/10	.0066	11	169.8	4.409	2	2	56.699
1/16	.0040	12	185.2	6.614	3	3	85.049
1/20	.0032	13	200.6	8.818	4	4	113.398
1/25	.0026	14	216.1	11.023	5	5	141.748
1/30	.0022	15	231.5	13.228	6	6	170.097
1/40	.0016	16	246.9	15.432	7	7	198.447
1/50	.0013	17	262.4	17.637	8	8	226.796
1/60	.0011	18	277.8	19.842	9	9	255.146
1/64	.0010	19	293.2				
1/100	.0006	20	308.6				
1/150	.00044						

Approximate Common Equivalents

16 minims	=	1 cubic centimeter
20 drops	=	1 cubic centimeter
75 drops	=	1 fluid dram
5 cubic centimeters	=	1 teaspoonful
3 teaspoonfuls	=	1 tablespoonful
4 fluid drams	=	1 tablespoonful
8 fluid drams	=	1 fluid ounce
2 tablespoonfuls	=	1 fluid ounce
16 fluid ounces	=	1 fluid pint
1 No. 2 level canful	=	1 dry pint
1 milligram per kilogram	=	0.007 grain per pound
1 ppm. (parts per million)	=	0.007 grain per pound
1 milligram per liter	=	1 ppm.
0.01 grain per pound	=	1.4 milligrams per kilogram
0.01 grain per pound	=	1.4 ppm.
1 grain	=	0.065 gram
1 minim	=	0.065 cubic centimeter
15 grains	=	1 gram
15 minims	=	1 cubic centimeter
1 dram	=	4 grams
1 fluid dram	=	4 cubic centimeters
1 ounce	=	30 grams
1 fluid ounce	=	30 cubic centimeters
1 milligram	=	1/60 grain

Air

1 cubic foot of air at temperature of 62° F., and at an atmospheric pressure of 14.7 pounds weighs 0.076097 pounds.

1 pound of air at a temperature of 62° F., and an atmospheric pressure of 14.7 pounds is 13.141 cubic feet in volume.

Volume of gas varies inversely as the pressure (Boyles Law).

Volume increases approximately 1/491 for each degree F. rise in temperature. (Charles Law).

Mean pressure of the atmosphere is 14.7 pounds per square inch at sea-level. (This equals one atmosphere).

Mensuration Rules

Area of rectangle = Length x Breadth.
Area of Triangle = Base x 1/2 perpendicular height.
Diameter of circle = Radius x 2.
π = 3.1416
Circumference of circle is equal to diameter x π
Area of circle equals diameter squared x 0.7854.

$$\text{Area of sector of circle} = \frac{\text{Area of circle x Number of degrees in arc}}{360}$$

Area of ellipse equals major axis x minor axis x 0.7854.
Solid contents of a cylinder equals length x area of cross section.
Solid contents of cone equals area of base x 1/3 vertical height.
Solid contents of frustum* of cone equals the sum of the areas of the two ends plus the square root of their product; multiply the sum thus obtained by 1/3 the vertical height.
Surface area of cylinder equals circumference x length + areas of the two ends.
Surface of hemisphere equals diameter x height x 3.1416.
Surface area of sphere equals diameter squared x 3.1416 or $4 \pi R^2$.
The area of the curved surface of a frustum of a cone equals the sum of the circumferences of the two ends of the frustum x 1/2 slant height of the frustum.

Conversion Tables

To convert:

Inches to centimeters	Multiply by 2.54
Yards to meters	Multiply by 0.9
Miles to kilometers	Multiply by 1.6
Square inches to square centimeters	Multiply by 6.45
Cubic inches to cubic centimeters	Multiply by 16.4
Pounds to kilograms	Multiply by 0.45
Cubic meters to cubic feet	Multiply by 35.3
Cubic feet to cubic meters	Multiply by 0.03
Cubic yards to cubic meters	Multiply by 0.76
Centimeters to inches	Multiply by 0.4
Meters to yards	Multiply by 1.1
Kilometers to miles	Multiply by 0.62
Square centimeters to square inches	Multiply by 0.155
Cubic centimeters to cubic inches	Multiply by 0.06
Cubic feet of water to pounds	Multiply by 62.4
Pounds of water to cubic feet	Multiply by 0.016
Cubic feet of water to gallons	Multiply by 7.48
Gallons of water to cubic feet	Multiply by 0.134
Gallons of water to pounds	Multiply by 8.34
Pounds of water to gallons	Multiply by 0.12
Gallons of water to liters	Multiply by 3.8
Liters of water to gallons	Multiply by 0.26

*Frustum is that part of a solid next to the base which is left after cutting off the top.

ADDENDUM I

Ragweed Pollenosis Control

General

The control of plants which produce nuisances or cause noxious effects on the population is the concern of public health. Such plants include ragweed, poison ivy, poison sumac, poison oak, marihuana, water hyacinths and algae. The proportion of the population affected by dermatitis from poison ivy, sumac, and oak is small but in certain areas such as around recreation centers the problem may become great enough to require the attention of the health authorities. The control of marihuana is important from the standpoint of addiction. Even where these do not produce problems great enough for public health intervention, an educational program for recognizing them would be of help. Water hyacinths, and algae may become a hazard or nuisance when growing in water used as a water supply source or when used for recreational purposes.

Hay fever, a Public Health Problem

However, hay fever, a distress caused by pollens from certain weeds, trees, and grasses, affects a large section of the population. It is estimated that about 25 million work days are lost each year due to hay fever and asthma. In the United States, three distinct hay fever seasons are recognized: Spring (March to early June) - caused by tree pollens, late spring and early summer (May to the end of July) - caused chiefly by grass pollens, and late summer and early fall (mid-August to frost) - caused by weed pollens, particularly ragweed pollens.

There is hardly any public health problem in the United States which is so widespread in its effects, so annoying and even debilitating, so wide-spread to the total population, so unnecessarily prevalent, and so amenable to known environmental control measures as is ragweed pollenosis. It has a case rate of 5,000 to 10,000 per 100,000 population. Estimates indicate that 80% to 90% of hay fever affections are due to ragweed. Forward looking public health workers have been considering this disease as within their domain for almost a half century, but only recently has impetus been developed to do something about it. Since ragweed growth is associated with man's practice of turning up the soil in the process of realizing his building genius and social needs, it can be said that hay fever is a disease of civilization and technological development, and is particularly an urban malady. Ragweed grows very quickly in areas where man has disturbed the surface soil. This is nature's reaction for preventing erosion where soil has been left bare. It is not found in areas shaded by trees or heavy growths of grasses, shrubs, and ferns.

Areas of heavy ragweed growth usually consist of strips, one to several feet in width along highways, or urban streets, and also immediately beside buildings. It appears that the heaviest growths of ragweed are associated with areas of the largest concentration of population, in many places in the center of towns. Usually ragweed areas are readily accessible for control.

Ragweed plants produce prolific amounts of yellow pollen, which causes inflammation, swelling, itching, and weeping of the upper respiratory and eye tissues.

Most places in the United States are infested with ragweed. Relief, however, for sufferers from ragweed pollenosis may be obtained in Bermuda, Nova Scotia, the Rocky Mountains; and some relief may be gotten in the southern tip of Florida, California, areas of heavily wooded sections of the upper Michigan peninsula, of Maine, and of Canada and some parts of the White and Adirondack Mountains.

Ragweed Control

Control of ragweed by pulling the weeds is not satisfactory since the disturbance of the soil resulting from this method serves to create heavier growths the following year. Cutting the weeds is not satisfactory unless done immediately prior to flowering, otherwise the plants will continue to develop flower heads and to pollenate. Soil sterilants are usually toxic to all

plants. Where ragweed is destroyed other plants must take over the area lest erosion supervene.

Since the discovery of the herbicide 2, 4-D (dichlorophenoxyacetic acid) in 1941, the technology of weed control was revolutionized. Many more herbicides have been subsequently synthesized. In 1955, more than 10% of the cultivated acreage in the United States was treated with these new herbicides to control weeds, a weed being defined as a plant growing where it is desired some other plant should grow. 2, 4-D destroys plants by causing excessive pathological growth. It kills (among other common plant pests) both the giant (Ambrosia trifida) and short (Ambrosia elatior) ragweed plants. This hormone is also lethal to most broad-leaf plants and to vegetables and flowers, but not to grasses. It is not toxic to man nor animal. The presence of 2, 4-D in soil can seriously retard the germination and growth of crop plants. After moist soil, containing 2, 4-D, has lain fallow for 2 to 6 weeks, the effects of this chemical disappears. In dry soil, 2, 4-D may reduce productivity for a year or longer. Nearly all germinating seeds are susceptible to 2, 4-D. It is extremely toxic to cotton plants. The minute quantities that light on cotton plants when the drift from adjacent applications is not controlled can cause severe injury. The danger has been thoroughly recognized since this weed killer was first introduced commercially in 1946, but despite adequate and repeated warnings, cotton may be found injured occasionally from drift, from accidental contamination of other chemicals used on cotton, or from improperly cleaned machinery and containers that have been used with 2, 4-D.

There are 3 general forms of 2, 4-D: the sodium salt, the amine salt, and the ester formulations. The esters are the most volatile and therefore most likely to cause injury to susceptible vegetation near the spraying area.

Excellent results are obtained by the application of 1/2 pound of actual 2, 4-D to each acre. In Louisiana the amine form is preferred as being safer because it is practically nonvolatile even under high temperature conditions, and because a little spray drift is not as harmful as a little spray drift of the ester form. In the Detroit program, 0. 1 pound 2, 4-D acid equivalent* per acre was used with good results. 2, 4-D is best used by diluting it in water. The amount of water used is not important as long as 1/2 pound of the chemical is uniformly applied to each acre. Five to 100 gallons of water have been used per acre. Where there is no danger of the spray drifting and injuring desirable plants, a low-volume rate is practical. In city lots and near valuable plantings, rates of 50 to 100 gallons per acre are safest. Low pressure applications ranging from 30 to 40 pounds per sq. inch will reduce the amount of drift of the spray.

2, 4, 5-T(trichlorophenoxyacetic acid) may also be used for ragweed control in the same dosage as 2, 4-D. Another successful formulation is 3/4 pound of 2, 4, 5-T in 10 to 15 gallons of water per acre. This is also effective against poison ivy, poison sumac, poison oak and other plants producing contact dermatitis. The spraying program for ragweed is carried on for about 16 weeks each year. This type of work should be under the supervision of competently trained men.

Tanks mounted on trucks, or small tanks carried by individual sprayers are used, depending upon the situation. Orchard type spray guns have been found satisfactory. The spray particles should not be too small lest they be carried too far or diverted too easily by air currents. Manufacturers market the concentrate in various formulations. Some add carbowax-1500 which significantly extends the period of effectiveness of the chemical. When other chemicals are added to 2, 4-D, it should be determined whether these are toxic to man or animals.

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*Dichlorophenoxyacetic acid is the active herbicidal part of the various forms of 2, 4-D. Since equal amounts of the various forms of 2, 4-D contain different quantities of this active factor, therefore, those quantities of each form of 2, 4-D which contain equal amounts of the active herbicidal factor are designated as acid equivalents, and can be expected to have equal herbicidal action. The sanitarian need not concern himself with the actual calculation used in determining the acid equivalents of the various forms of 2, 4-D, since the acid equivalent of each compound is given on the label of the material.

Best results are obtained when 2, 4-D is applied just before the flower buds open. Low temperatures and low soil moisture reduce the effectiveness of 2, 4-D to some extent.

In 1948, the ragweed control project in New Hampshire cost about $2.00 for each mile of highway on both sides, including labor, chemical, and truck mileage.

An inexpensive method to clean spray tanks of 2, 4-D is: (1) Rinse the tank and nozzle with water; (2) fill it almost to capacity with hot water at about 180° F.; (3) add household amonia at the rate of 2 teaspoonsful to each quart of water; (4) complete filling the tank with hot water; (5) stir, and close tank; (6) spray small amount thru nozzle to rinse it; (7) allow water to remain in tank for about 18 hours; (8) drain; (9) rinse the tank and nozzle twice with water.

Water hyacinths are controlled by spraying 1 to 4 pounds of 2, 4-D acid equivalent per acre in 2 to 150 gallons of water.

Program Development

The launching of a program involves the following:

1. Surveying the scope and nature of the problem. Whether other crops may be affected.
2. Developing a broad educational plan to win support for the program.
3. Deciding on the methods and techniques to be used.
4. Organizing the operations in such manner as to take advantage of the meteorological factors, and of the available equipment, manpower, and funds.
5. Devising a method of evaluation and reporting, and computing costs.
6. Knowing as much as possible about the program in order to be able to answer critical questions, particularly if results obtained should be less than the public expected.

Evaluation of Control Program

The evaluation of a spraying program is carried out by measurement of pollen concentrations in various parts of the control area to determine whether spraying has had any significant effect in reducing the pollen counts, by questioning drug stores as to whether the sales of anti-histamines have been reduced, by questioning physicians concerning the well-being of their hay fever patients, and by questioning the hay fever sufferers themselves.

A conservative estimate of a season's production of pollen from an acre of healthy ragweed is 50 to 60 pounds. Several thousand acres of ragweed could therefore product tens and tens of tons of pollen.

In order to be able to pinpoint our efforts in a ragweed control program, we must determine what areas should be given priority. Such information can be obtained by the pollen count which indicates the degree of pollen concentration in the atmosphere. A locality with a pollen count of 5 or less may be considered as free of ragweed pollen. Counts of 5 to 15 are considered moderately free from significant concentration; in such an area acute hay fever discomfort should not last more than a few days. If the count be above 15, heavy pollen densities are definitely indicated. A pollen count on any one day of 25 or more will usually be accompanied by hay fever symptoms. Because meteorological conditions will markedly effect pollen concentrations, therefore the classification of an area as to the degree to which it is affected by pollen should be estimated on the basis of a five year average. Free areas are usually found in undeveloped places. Forested and hilly areas are usually fairly free of ragweed pollen.

In making a survey of an area, about 50 slides should be made on successive days from about August 12 to October 1. The count is made under the magnification of 75X. Pollen counts are taken at various designated stations in the area at a level of about 5 feet above ground, and on top of some 7 or 8 story buildings where extraneous turbulence factors are reduced to a minimum. The Detroit study indicated that taking counts on such buildings added no significant information. Stations located more than a mile from a field or from a patient may have little value in gauging the effective pollen concentration in that vicinity.

Pollen concentration counts are made by the microscopic slide method, and by the

volumetric method. The Academy of Allergy has recommended a Standard Technique for the slide method. This method is described in detail in the Journal of Allergy Vol. 17, p. 178, 1946, and consists essentially of placing a microscope slide in a shelter composed of 2 parallel steel discs, 3 inches apart, the slide holder being raised 1 inch above the surface of the lower disc. The upper surface of the slide is prepared with petrolatum as an adhesive. The number of pollen grains counted per sq. cm. on the slide after 24 hours exposure is the microscope slide count. The indirect volumetric method, developed by Durham and accepted by the Academy of Allergy, is done by calculation as follows: The 24 hour pollen count per sq. cm. x 36 (conversion factor for ragweed) = average ragweed pollen grains per cubic yard of air in 24 hours. Each type of pollen or spore has its own conversion factor.

The Bureau of Industrial Hygiene of Detroit has devised a membrane filter technique for a direct volumetric method which eliminates the uncertainties inherent in the calculations using conversion factors, but is more complicated and elaborate to perform. This consists essentially of a battery of valves with molecular filter membranes, connected to an air pump, and controlled by electrically operated valves. In order to obtain samples automatically at various times during each day, a timing device and a rotary switch are added. By taking samples at regular intervals during the day, a daily profile of the pollen concentration can be obtained. The filter retains all aero-allergens of particle sizes greater than 0.2 microns from the volume of air which passes through it. It is necessary to know the rate of flow of air through the pump to calculate the pollen concentration. In order to make the count, the filter is removed from the valve and placed on a black background for contract, and then mounted in a simple manner as described by Cryst, Gurney and Hansen in their articles, "A Method for Determining Aero-Allergens Concentration with the Molecular Filter Membrane," Journal of Laboratory and Clinical Medicine, Vol. 46, p. 471, 1955; and "Aero-allergen Studies with Molecular Filter Membrane", Journal of Allergy, Vol. 26, p. 533, 1955. Since there appears to be a lack of precise correlation between fluctuations of aero-allergen concentration and severity of patients' symptoms, there does not seem to be sufficient reason at this time to recommend the replacement of the simple microscope slide method of sampling by a more precise, though more complicated, volumetric method of sampling. For the time being, the latter method should be reserved for research.

The Detroit experiment appears to contradict the widely held theory that pollen is dispersed and transported in significant concentrations for hundreds of miles. It concluded instead, that nearly all of the pollen found on the microscope slides was produced in the immediate vicinity. Since it appears that allergic persons suffer noticeable symptoms mostly after massive doses of pollen grains, and since pollen concentrations from far distances are usually of low densities, therefore, local control programs can be effective and should become a routine public health activity.

Although ragweed is an annual plant, seeds remain viable for many years awaiting some disturbance of the soil. If soil be left alone, grass will eventually (10 or more years) crowd out ragweed. If ragweed be destroyed by spraying, grass will take over very rapidly. Ragweed control is therefore not an endless task. A ragweed-free community is attainable. It is, however, much more easily attained with the backing of a weed-control ordinance.

The Sanitarian should be mindful that there are also other plants which cause extreme discomfort to people, such as poison ivy. Such plants can also be destroyed by spraying with chemicals.

The Health Department's Role

Public Health organizations must accept their responsibility in the field of ragweed control. In local jurisdictions, local health departments may initiate and carry out such control and may cooperate in joint projects with other divisions and local government. State Health Departments should, at least, serve as consultants to highway departments in such projects, and should prepare lists of places where there is essentially no ragweed in order to be able to make such information available to people concerned with the problem of ragweed pollenosis.

ADDENDUM II

Standards, Ordinance, and Regulations for Emergency Ambulance Service

A Model Ordinance Regulating Ambulance Service

(The Policy Committee of the Joint Action Program sponsored by the American College of Surgeons, The American Association for the Surgery of Trauma, and the National Safety Council requested the Traffic Conference to develop a model ordinance regulating ambulance service, the result being the approval of this Ordinance October 27, 1963.)

An Ordinance to Regulate the Licensing, Inspection and Operation of Ambulances, to Provide Standards for the Licensing of Ambulances and of Ambulance Drivers, Attendants, and Attendant-Drivers, to Provide for Renewal and Revocation of Licenses, to Require Written Reports, to Provide for Traffic Regulations of Ambulances, and to Establish Penalties for Violation of its Provisions.

The (_____) of (_____) ordains as follows:
enacting body city or county

Section 1. Definitions.

(a) "Ambulance" means any privately- or publicly-owned motor vehicle that is specially designed or constructed, and equipped, and is intended to be used for and is maintained or operated for the transportation of patients, including dual purpose police patrol cars and funeral coaches or hearses which otherwise comply with the provisions of this Ordinance, except any such motor vehicle owned by, or operated under the direct control of, the United States.

(b) "Attendant" means a trained and/or qualified individual responsible for the operation of an ambulance and the care of the patients whether or not the attendant also serves as driver.

(c) "Attendant-Driver" means a person who is qualified as an attendant and a driver.

(d) "Driver" means an individual who drives an ambulance.

(e) "Dual purpose police patrol car" means a vehicle, operated by a police department, which is equipped as an ambulance, even though it is also used for patrol or other police purposes.

(f) "Health Officer" means the (_____) Health officer or other
city or county
designated official.

(g) "License Officer"* Means the (_____) (_____
city or county designated
_____).
officer

(h) "Patient" means an individual who is sick, injured, wounded, or otherwise incapacitated or helpless.

(i) "Person" means any individual, firm, partnership, association, corporation, company, group of individuals acting together for a common purpose or organization of any kind, including any governmental agency other than the United States.

Section 2. License Required*

(a) No person, either as owner, agent or otherwise, shall furnish, operate, conduct, maintain, advertise, or otherwise be engaged in or profess to be engaged in the business or service

*Where there is a Health Officer, he should be designated as the License Officer.

of the transportation of patients upon the streets, alleys, or any public way or place of (_____) unless he holds a currently valid license for an ambulance, city or county
issued pursuant to this Ordinance. An ambulance operated by an agency of the United States shall not be required to be licensed hereunder.

(b) No ambulance shall be operated for ambulance purposes, and no individual shall drive, attend or permit it to be operated for such purposes on the streets, alleys, or any public way or place of (_____) unless it shall be under the immediate supervision and direction of a person who is holding a currently valid license as an attendant-driver or attendant. city or county

(c) Provided however, that no such licenses shall be required for an ambulance, or for the driver, attendant or attendant-driver of an ambulance, which

(i) is rendering assistance to licensed ambulances in the case of a major catastrophe or emergency with which the licensed ambulances of (_____) are insufficient or unable to cope; or city or county

(ii) is operated from a location or headquarters outside of (_____) in order to transport patients who are picked up beyond the limits of (_____) to locations within (_____), but no such outside ambulance shall be used to pick up patients within (_____) for transportation to locations within (_____) unless the driver, attendant and attendant-driver and the person subject to the provisions of Section 2(a) of this Ordinance in respect of such ambulance, hold currently valid licenses issued pursuant to this Ordinance. city or county city or county city or county city or county

Section 3. Application for Ambulance License. Applications for ambulance licenses hereunder shall be made upon such forms as may be prepared or prescribed by the License Officer and shall contain:

(a) The name and address of the applicant and of the owner of the ambulance.

(b) The trade or other fictitious name, if any, under which the applicant does business and proposes to do business.

(c) The training and experience of the applicant in the transportation and care of patients.

(d) A description of each ambulance, including the make, model, year of manufacture, motor and chasis number; current state license number; the length of time the ambulance has been in use; and the color scheme, insignia, name, monogram or other distinguishing characteristics to be used to designate applicant's ambulance.

(e) The location and descriptions of the place or places from which it is intended to operate.

(f) Such other information as the License Officer shall deem reasonably necessary to a fair determination of compliance with this Ordinance.

(g) An accompanying license fee of $_____.

Section 4. Standards for Ambulance License

(a) Each ambulance shall, at all times when in use as such,

(i) be suitable for the transportation of patients from the standpoint of health, sanitation and safety, and be maintained in suitable premises;

(ii) contain equipment conforming with the standards, requirements and regulations provided for herein, which equipment shall be in proper and good condition for such use;

(iii) currently comply with all applicable laws and local ordinances relating to health, sanitation and safety;

(iv) be equipped with such lights, sirens and special markings to designate it as an ambulance as may be prescribed in reasonable regulations promulgated by the License Officer; and

(v) be equipped with approved safety belts for the driver, and for a passenger in the

front seat if such seat be provided.

(b) Any change of ownership of a licensed ambulance shall terminate the license and shall require a new application and a new license and conformance with all the requirements of this Ordinance as upon original licensing.

(c) Application for transfer of any ambulance license to another or substitute vehicle shall require conformance with all the requirements of this Ordinance as upon original licensing. No ambulance license may be sold, assigned, mortagaged or otherwise transferred without the approval of the License Officer and a finding of conformance with all the requirements of this Ordinance as upon original licensing.

(d) Each licensed ambulance, its equipment and the premises designated in the application and all records relating to its maintenance and operation as such, shall be open to inspection by the Health Officer or his designated representatives during usual hours of operation.

(e) No official entry made upon a license may be defaced, removed or obliterated.

Section 5. Standards for Ambulance License—Liability Insurance. (a) No ambulance license shall be issued under this Ordinance, nor shall such license be valid after issuance, nor shall any ambulance be operated in (_____) unless there be at all times
city or county
in force and effect insurance coverage, issued by an insurance company licensed to do business in the State of (_____), for each and every ambulance owned and/or operated by or for the applicant or licensee, providing for the payment of damages;

(i) for injury to or death of individuals in accidents resulting from any cause for which the owner of said vehicle would be liable on account of liability imposed on him by law, regardless of whether the ambulance was being driven by the owner or his agent, and

(ii) for the loss of or damage to the property of another, including personal property, under like circumstances, in such sums and under such terms as may be required in regulations promulgated by the License Officer.

(b) Said insurance policies shall be submitted to the License Officer for approval prior to the issuance of each ambulance license. Satisfactory evidence that such insurance is at all times in force and effect shall be furnished to the License Officer, in such form as he may specify, by all licensees required to provide such insurance under the provisions of this Ordinance.

(c) Every insurance policy required hereunder shall contain a provision for a continuing liability thereunder to the full amount thereof, notwithstanding any recovery thereon, that the liability of the insurer shall not be affected by the insolvency or the bankruptcy of the assured, and that until the policy is revoked the insurance company will not be relieved from liability on account of non-payment of premium, failure to renew license at the end of the year, or any act or omission of the named assured. Such policy of insurance shall be further conditioned for the payment of any judgments up to the limits of said policy, recovered against any person other than the owner, his agent or employee, who may operate the same with the consent or acquiescence of the owner.

(d) Every insurance policy required hereunder shall extend for the period to be covered by the license applied for and the insurer shall be obliged to give not less than _____ days written notice to the License Officer and to the assured before any cancellation or termination thereof earlier than its expiration date and the cancellation or other termination of any such policy shall automatically revoke and terminate the licenses issued for the ambulances covered by such policy, unless another insurance policy complying with the provisions of this section shall be provided and be in effect at the time of such cancellation or termination.

Section 6. Duties of License Officer (a) The License Officer shall, within _____ days after receipt of an application for an ambulance license as provided for herein, cause such investigation as he deems necessary to be made of the applicant and of his proposed operations.

(b) The License Officer shall issue a license hereunder for a specified ambulance, to be valid for a period of _____ years unless earlier suspended, revoked or terminated, when he finds:

(i) That the public convenience and necessity require the proposed ambulance service.

(ii) That each such ambulance, its required equipment and the premises designated in the application, have been certified by the Health Officer as provided for herein.

(iii) That the applicant is a responsible and proper person to conduct or work in the proposed business.

(iv) That only duly licensed drivers, attendants and attendant-drivers are employed in such capacities.

(v) That all the requirements of this Ordinance and all other applicable laws and ordinances have been met.

Section 7. Duties of Health Officer (a) Prior to the issuance of any ambulance license hereunder, the Health Officer shall cause to be inspected the vehicles, equipment and premises designated in each application hereunder, and shall certify his approval in a written report to the License Officer when he finds compliance with the standards prescribed in Section 4(a) and in Section 8 of this Ordinance, and with the regulations promulgated under such sections; Provided, however, that under the terms of this Ordinance the Health Officer shall have no responsibility, and shall exercise no authority, in connection with laws and ordinances of general applicability which deal with motor vehicle inspection.

(b) Subsequent to issuance of an ambulance license hereunder, the Health Officer shall cause to be inspected each such licensed vehicle, and its equipment and premises, whenever he deems such inspection to be necessary but in any event no less frequently than twice each year, and shall promptly report his findings in a written report to the License Officer. The periodic inspection required hereunder shall be in addition to any other safety or motor vehicle inspection required to be made for ambulances or other motor vehicles, or other inspections required to be made, under general law or ordinances, and shall not excuse compliance with any requirement of law or ordinance to display any official certificate of motor vehicle inspection and approval nor excuse compliance with the requirements of any other applicable general law or ordinance.

(c) A copy of each initial, semi-annual or other ambulance, equipment and premises inspection report submitted by the Health Officer to the License Officer under the provisions of this section shall be promptly transmitted to the applicant or licensee to whom it refers.

Section 8. Standards for Ambulance Equipment (a) Required equipment in each ambulance shall include, at all times when the ambulance is in use as such, equipment adequate in the judgment of the Health Officer for dressing wounds, splinting fractures, controlling hemorrhage, and providing oxygen.

(b) The Health Officer is authorized and directed to promulgate regulations, after public notice and opportunity for public hearing, to implement the standards provided herein as to required equipment in ambulances. In determining the adequacy of equipment, the Health Officer shall take into consideration the current list of minimal equipment for ambulances, adopted by the American College of Surgeons or its duly authorized Committee on Trauma. Each licensee of an ambulance shall comply with such reasonable regulations hereunder as may be promulgated by the Health Officer and shall maintain in each such ambulance, at all times when it is in use as such, all such equipment as may be prescribed by the Health Officer hereunder.

Section 9. Applications for Drivers, Attendants and Attendant-Drivers License: Applications for drivers, attendants and attendant-drivers licenses hereunder shall be made upon such forms as may be prepared or prescribed by the License Officer and shall contain:

(a) The applicant's full name, current residence, places of residence for _____ years previous to moving to his present address, and length of time he has resided in (_____ city _____ or county).

(b) The applicant's age, marital status, height, color of eyes and hair.

(c) Whether he has ever been convicted of a felony or misdemeanor, and if so, when and where and for what cause.

(d) The applicant's training and experience in the transportation and care of patients, and whether he has previously been licensed as a driver, chauffeur, attendant or attendant-driver, and if so, when and where, and whether his license has ever been revoked or suspended in any jurisdiction and for what cause.

(e) Affidavits of good character from two reputable citizens of the United States and residents of (_____) who have personally known such applicant and observed
city or county
his conduct during _____ years next preceding the date of his application.

(f) Two recent photographs of the applicant, of a size designated by the License Officer, one of which shall be attached by the License Officer to the license.

(g) Such other information as the License Officer shall deem reasonably necessary to a fair determination of compliance with this Ordinance.

(h) An accompanying license fee of $_____.

Section 10. Standards for Drivers, Attendants and Attendant-Drivers License. (a) The License Officer shall, within a reasonable time after receipt of an application as provided for herein, cause such investigation as he deems necessary to be made of the applicant for a drivers, attendants or attendant-drivers license.

(b) The License Officer shall issue a license to a driver, attendant or attendant-driver hereunder, valid for a period of _____ years, unless earlier suspended, revoked or terminated, when he finds that the applicant

(i) is not addicted to the use of intoxicating liquors or narcotics, and is morally fit for the position;

(ii) is able to speak, read and write the English language;

(iii) has been found by a duly licensed physician, upon examination attested to on a form provided by the Health Officer, to be of sound physique, possessing eyesight corrected to at least 20/40 in the better eye, and free of physical defects or diseases which might impair the ability to drive or attend an ambulance; and

(iv) for each applicant for attendant or attendant-drivers license, that such applicant has a currently valid certificate evidencing successful completion of a course of training equivalent to the advanced course in first aid given by the American Red Cross or the United States Bureau of Mines.

Provided however, that no one shall be licensed as a driver or attendant-driver unless he holds a currently valid chauffeur's permit from the State of (_____).

(c) A license as driver, attendant or attendant-driver issued hereunder shall not be assignable or transferable.

(d) No official entry made upon a license may be defaced, removed, or obliterated.

Section 11. Renewal of License. Renewal of any license hereunder, upon expiry for any reason or after revocation, shall require conformance with all the requirements of this Ordinance as upon original licensing.

Section 12. Revocation of License. (a) The License Officer may, and is hereby authorized to, suspend or revoke a license issued hereunder for failure of a licensee to comply and to maintain compliance with, or for his violation of, any applicable provisions, standards or requirements of this Ordinance, or of regulations promulgated hereunder, or of any other applicable laws or ordinances or regulations promulgated thereunder, but only after warning and such reasonable time for compliance as may be set by the License Officer. Within _____ days after a suspension, the licensee shall be afforded a hearing, after reasonable notice. The License Officer shall, within _____ days after conclusion of such hearing, issue a written decision (which shall include written findings) as to the suspension of said license. Such written decision shall be promptly transmitted to the licensee to whom it refers.

(b) The initial, semi-annual or other ambulance, equipment and premise inspection reports

of the Health Officer herein provided for shall be prima facie evidence of compliance or non-compliance with, or violation of, the provisions, standards and requirements provided herein, and of the regulations promulgated hereunder, for the licensing of ambulances.

(c) Upon suspension, revocation or termination of an ambulance license hereunder, such ambulance shall cease operations as such and no person shall permit such ambulance to continue operations as such. Upon suspension, revocation or termination of a drivers, attendants or attendant-drivers license hereunder, such driver, attendant or attendant-driver shall cease to drive or attend an ambulance and no person shall employ or permit such individual to drive or attend an ambulance.

Section 13. Reports. (a) Within _____ hours after transporting any patient within (_____), or from one place within (_____) to another
city or county city or county
place within or beyond its limits, the licensee of an ambulance hereunder shall file a written report with such (_____) of (_____) upon such form
designated official city or county
as they may provide or prescribe, giving all information therein required and any other relevant information which such (_____) may require.
designated official

(b) The provisions of subsection (a) of this section shall apply with equal force in case such patient shall die before being so transported in such ambulance or dies while being transported therein or at any time prior to the acceptance of the patient into the responsibility of the hospital or medical or other authority if the patient is still under the care or responsibility of the ambulance.

Section 14. Obedience to Traffic Laws, Ordinances and Regulations. (a) The driver of an ambulance, when responding to an emergency call or while transporting a patient, may exercise the privileges set forth in this section, but subject to the conditions herein stated, and only when such driver has reasonable grounds to believe that an emergency in fact exists requiring the exercise of such privileges.

(b) Subject to the provisions of subsection (a) hereof, the driver of an ambulance may

(i) Park or stand, irrespective of the otherwise applicable provisions of law, ordinance or regulation;

(ii) Proceed past a red or stop signal or stop sign, but only after slowing down as may be necessary for safe operation;

(iii) Exceed the maximum speed limits permitted by law, ordinance or regulation so long as he does not endanger life or property; and

(iv) Disregard laws, ordinances or regulations governing direction or movement or turning in specified directions.

(c) The exemptions herein granted shall apply only when such ambulance is making use of audible and visual signals meeting the requirements of law, ordinance or regulation.

(d) The foregoing provisions shall not relieve the driver of an ambulance from the duty to drive with due regard for the safety of all persons, nor shall such provisions protect the driver from the consequences of his reckless disregard for the safety of others.

Section 15. Penalties. (a) Any person violating, or failing to comply with, the provisions of Section 2 (a) of this Ordinance and the applicable provisions hereof relating to the licensing of ambulances, shall be deemed guilty of a misdemeanor and upon conviction thereof shall be fined an amount not exceeding $_____ or imprisoned for a period not exceeding _____ days, or be both so fined and imprisoned, for each offense.

(b) Any person violating, or failing to comply with, any other provision of this Ordinance shall be deemed guilty of a misdemeanor and upon conviction thereof shall be fined an amount not exceeding $_____ or be imprisoned for a period not exceeding _____ days, or be both so fined and imprisoned, for each offense.

(c) Each day that any violation of, or failure to comply with, this Ordinance is committed or permitted to continue shall constitute a separate and distinct offense under this section and shall be punishable as such hereunder; provided, however, that the Court may, in appropriate cases, stay the cumulation of penalties.

Section 16. Separability. If any section, subsection, sentence, clause, phrase or portion of this Ordinance is for any reason held invalid or unconstitutional by any court of competent jurisdiction, such portion shall be deemed a separate, distinct and independent provision and such holding shall not affect the validity of the remaining portions hereof.

Section 17. Effective Date. This Ordinance shall become effective on (_____ date).

Section 18. Ordinances Repealed. All ordinances and parts of ordinances in conflict with the provisions of this Ordinance are hereby repealed as follows:

_____

_____

_____

_____

Adopted this _____ day of _____, 19__.

Standards for Emergency Ambulance Services

These Standards, developed by the Committee on Trauma of American College of Surgeons, and approved by its Board of Regents in February, 1967, include requirements for appraisal and immediate care at the site of injury or illness, followed by safe and comfortable transportation to a hospital as should be done by any organization operating an emergency ambulance service. All such services should be under continuing supervision. The Committee believes that lives can be saved if ambulance personnel be well trained, ambulance vehicles be equipped adequately and operated safely, and all communities and operators insist upon meeting and maintaining high standards for the organization and operation of emergency ambulance services.

These Standards are desirable, but if some be impractical for a given community, they should remain as ideals to be approached as nearly as possible.

Organization and operation

In each community, the health department or other governmental agency should obtain the authority to regulate all public and private ambulance services. (If enabling legislation be required for such authority, the local government should request it from the state legislature immediately.)

A state, county or municipal agency should be responsible for determining the need for public and private ambulance services, licensing each service and enforcing these standards.

The operator of an ambulance service should be legally and morally responsible for the conduct of the organization and operation.

A manual of ambulance service policies and standards should be available for use by all personnel.

Liaison between the staff of an ambulance service and the law enforcement authorities, the medical profession, hospital administrators, and the public is important. A periodic review of ambulance reports, correspondence, complaints and violations is an excellent means of

promoting rapport among all interested parties.

The privately-owned company should be financially responsible, and it should carry adequate public liability insurance. Reasonable charges, predicated on services provided and on operating costs, should be posted with, and approved by, the licensing authority.

Twenty-four hour, year-round coverage should be available.

All ambulance personnel should respect local fire, building, health and traffic regulations, including disaster plans.

The Committee on Trauma recommends that the model ordinance regulating ambulance service presented following these standards and equipment, and distributed by the National Safety Council be used as a guide by local authorities for any necessary legal action.

Standby ambulance service should be established with other operators in adjacent areas.

A record of all violations of the law should be kept by the operator of the ambulance service. He also should keep a record of any accidents in which his vehicles are involved.

Personnel

At least two trained persons, a driver and an attendant, or two driver-attendants, should man each ambulance dispatched.

The driver's ability to drive and the attendant's competence in emergency care should be certified by the licensing authority. The employer should be accountable for the character and moral conduct of those whom he employs.

Before an applicant - driver or attendant - is certified, the licensing authority should determine that he (1) is not addicted to alcohol or drugs, and (2) has not been convicted of a felony.

The applicant should be examined by a physician. The applicant should have a sound body, eyesight of at least 20/40 in the better eye, and no physical defects which might impair his ability to drive or attend an ambulance. Provisions for periodic examination should be made. He should speak, read and write English. He should hold a current certificate of completion of an advanced first-aid course given by the Red Cross, the U.S. Bureau of Mines, St. John Ambulance Association or the equivalent; and he should be certified as proficient in external cardiac compression and in handling emergency childbirth and persons with acute mental conditions.

The ambulance attendant should record all calls, describing them in detail.

An advisor who is a doctor of medicine is recommended to provide continuing refresher training.

Vehicles

The casualty-carrying vehicle should provide easy loading, privacy and comfortable riding. There should be adequate space for the attendant to continue care while the patient is in transit. Driver's and patient's compartments should be separate. Good illumination and temperature control of the patient area are required.

The vehicle should start and stop slowly and smoothly, and travel at a safe speed. Jostling and speed may be harmful and dangerous to the patient.

The ambulance should be equipped with warning devices, according to state or local statute.

The ambulance should be kept clean, and supplied with fresh linen for each call. After it has transported a patient with a communicable disease, the vehicle must be cleansed thoroughly before it is used for another call.

Equipment

Minimal equipment for the ambulance is listed hereinafter.

The vehicle and equipment should be inspected at least annually for safety and good mechanical condition. Attendants also should be tested annually to assure that they are using the equipment correctly.

Communications

All vehicles should be equipped with a two-way radio capable of clear transmission and reception over not less than 20 miles.

A dispatching office with an adequate communications system, a time-recording device, and adequate space for records should be set up. On all shifts, the dispatcher should have at least as much training as the ambulance personnel so that he can receive and transmit reliable information as to the injury or illness.

Other factors

Many other items need to be standardized. In some instances, there is no general agreement as yet; in others, there is not enough experience with what seem to be good suggestions. In still other instances, local conditions influence the base lines.

For example, consideration should be given to: The relation of ambulance services to rescue operations; the wearing of uniforms, name plates or arm bands; the exact content of ambulance records and to whom copies should be made available; the detailed requirements for a casualty-carrying vehicle; and easy interchange of equipment between ambulances and hospitals; the possible need of sirens; and closer communications between ambulances and hospital emergency departments.

For these, the Committee on Trauma is not yet ready to establish standards.

The equipment considered by the Committee on Trauma to be the minimum with which trained ambulance drivers and attendants can give adequate care at the site of an accident are as follows:

1. Hinged half-ring lower extremity splint with webbing ankle hitch.
2. Two or more padded boards 4 1/2 feet long by 3 inches wide, and two or more similar padded boards 3 feet long by 3 inches wide, of material comparable to four-ply wood, for coaptation splinting of fracture of leg or thigh.
3. Two or more padded 15-inch by 3-inch wood of cardboard splints for fractures of the forearm.
4. Short and long spine boards with accessories.
5. Oxygen tanks and masks of assorted sizes.
6. Hand-operated bag-mask resuscitation unit with adult-, child-, and infant-size masks, a unit which can be attached to oxygen supply being preferred.
7. Simple suction apparatus with catheter.
8. Mouth-to-mouth, two-way resuscitation air-ways for adults and children.
9. Oropharyngeal airways.
10. Mouth gags made of three tongue blades taped together and padded.
11. Universal dressing, approximately 10 inches by 36 inches, packaged folded to 10 inches by 9 inches.
12. Sterile gauze pads.
13. One-, 2-, and 3-inch adhesive tape on cylinder.
14. Six-inch by 5-yard soft roller-type bandages.
15. Triangular bandages.
16. Safety pins, large size.
17. Shears for bandages.
18. Several pillows.

The foregoing is a revision of an original list established by the Committee on Trauma in 1961 which has become the standard for ambulance services throughout the United States and Canada.

The list does not contain a tourniquet and elastic bandages. The Committee on Trauma hopes that thus forcing an attendant to improvise a tourniquet will make him think carefully before using one and so minimize indiscriminate use.

To eliminate the danger of deleterious pressure due to improperly applied elastic bandages, soft roller-type bandages are used instead.

The hand-operated bag-mask is superior to the mechanical resuscitator or pulmotor as it is simply constructed, performs adequately, and pressure adjustments may be made by the operator immediately by simply changing his hand pressure. The hand-operated mask is also much less costly than the resuscitator or pulmotor.

The major advantage of the bag-mask is that it permits the rescuer to direct his attention to the patient rather than to the apparatus.

The short and long spine boards are essential for safe removal of various accident victims, especially those with actual or suspected injuries to the spine. The straps of two inch belting should be at least eight feet long and equipped with friction catches, such as those on safety belts used in automobiles. While various kinds of short spine boards are in use, the one desired here is similar to that described in the Journal of Trauma (September, 1966).

The universal dressing on the list unfolds to either 10 by 18 inches or 10 by 36 inches, and affords adequate coverage for any wound.

The universal dressing may also be used as padding for splints; and, when two dressings are folded lengthwise, they form an efficient cervical collar.

Some types of suction apparatus for ambulance use are given below. Ideally, a unit should have at least 10 inches of vacuum in inches of mercury.

This list of equipment is minimal, the Committee on Trauma emphasizes, and, depending on local conditions and decisions, other items may be added.

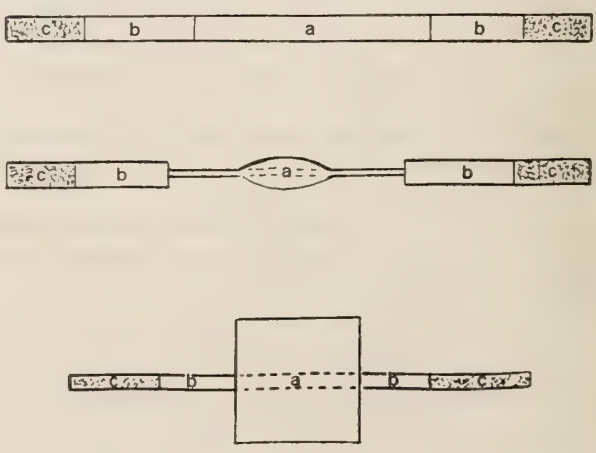
As inflatable splints are not considered suitable for a list giving only "minimal" equipment, they are not included here. The Committee on Trauma approves their use for fractures at and below the knee joint provided the foot be included; and at and below the elbow joint provided the hand be included; and provided that the splint be inflated by lung pressure only.

Equipment for Short Board (see illustrations)

Headband measures 42 inches
- a. Padded section
- b. Thin webbing 2 inches wide
- c. Strip of looped or pile velcro

Chin Strap measures 42 inches
- a. Regulation football chin strap
- b. Thin webbing 2 inches wide
- c. Strip of looped or pile Velcro

Neck Roll measures 32 inches
- a. Foam rubber roll is 8 inches wide and 8 inches in diameter, covered for protection first with plastic, then stockinette, both disposable and easily replaceable
- b. Thin webbing 1-inch wide
- c. Strip of looped or pile Velcro



Equipment for Short Board

Velcro is a fastener. It consists of two strips of nylon tape — one covered with minute hooks, the other with minute loops

forming a pile surface — which lock securely when pressed together, open when peeled apart.

The detail of the spine boards and the accessories which accompany them are shown in the illustrations.

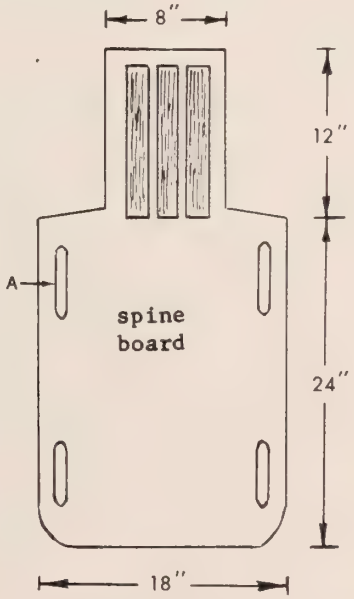
The boards are made from 3/4 inch marine plywood finished on both sides. Both surfaces are well sanded, shellacked or varnished, and waxed.

Each board is equipped with two straps made of belting 2 inches wide and 8 feet long and equipped with friction buckle.

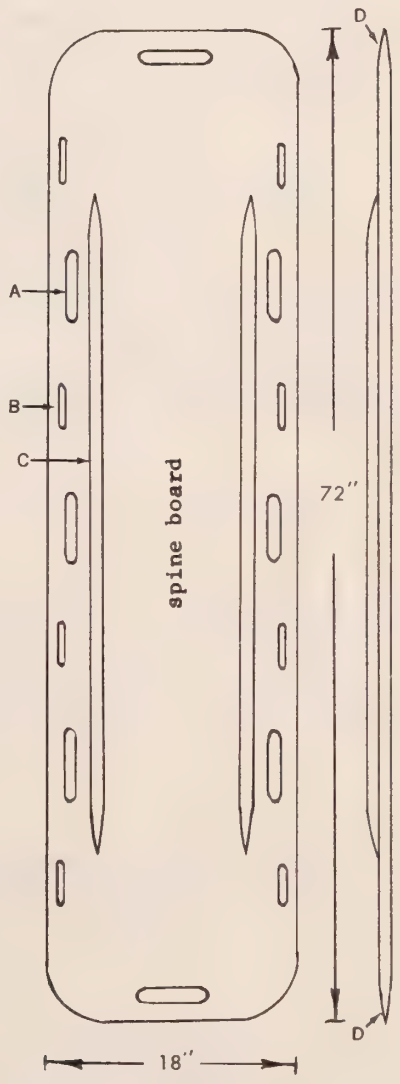
Handholds, indicated by "A," which can also double as strap holes, measure 5 by 1 1/4 inches and are 1 1/4 inches from the edge of the board. Handhold edge is rounded.

Strap holes, indicated by "B," measure 1/2 by 3 inches and are 3/4 of an inch from the edge of the board.

Position of:
Headband
Chin strap
Neck roll



Back View
Short Board
(Hooked-surface Velcro strips on head piece)



Back View
Long Board

One-inch half/rounds with tapered ends, indicated by "C," elevate the long board so that bearers can insert fingers through the handholds. Tapered ends of half/rounds prevent board from catching as it is pushed under the patient.

Both ends of the long board and the bottom end of the short board, indicated by "D," are tapered so that the boards will slide as easily as possible when pushed under or behind the patient.

Ends (looped or pile Velcro) of straps grab strips of Velcro with hook surface affixes to back of head piece on short board.

Position of headband, chin strap and neck roll is demonstrated.

Suction Units for Ambulance Use

(Note: All units can be accommodated in a 12-inch cube.)

Manufacturer or Supplier	Mode of Operation	Vacuum in Inches of Mercury	Rate of Flow-Water
Air-Shields, Inc. Jacksonville Road Hatboro, Pennsylvania	Pedal (AMBU unit)	12"	200 cc. in 10 sec.
DeVilbiss Co. Somerset, Pennsylvania	Motor*, from car battery 12 V, D. C. (#712 suction pump)	2"-22" adjustable with gauge	1 liter in 22 sec.
J. H. Emerson Co. 22 Cottage Park Avenue Cambridge 40, Massachusetts	Manual	1"	100 cc. in 10 sec.
Globe Safety Products, Inc. 125 Sunrise Place Dayton, Ohio	Manual	4"	No Data
Globe Safety Products, Inc.	Manual	8"	No Data
Gomco Surgical Mfg. Corp. 828 East Ferry Street Buffalo11, New York	Motor*, from car battery 12 V., D. C.		2,800 cc. per m.
National Medical Pumps Box 238 Boonton, New Jersey	Motor**, from car battery 12 V., D. C.	15"	6 liters per m.

* Unit has cigarette lighter type of plug-in for use inside ambulance, but might possibly be adapted for use with hot-shot battery.

** Unit can be operated in or out of ambulance with 12-volt hot-shot battery.

Ambulance Services

The following is taken from the Summary Report of the Task Force on Ambulance Services of the Committee on Trauma, American College of Surgeons, 1967.

Training of Personnel

A standard course of instruction is sorely needed. The Committee on Trauma of the American College of Surgeons has recently published a manual, edited by Dr. Robert H.

Kennedy, entitled "Emergency Care of the Sick and Injured - A Manual for Law-Enforcement Officers, Fire-Fighters, Ambulance Personnel, Rescue Squads and Nurses". This text could well serve as a nationally endorsed manual and a guide to development of uniform requirements for certification of ambulance attendants, necessary training aids, and standardized courses of instruction.

Vehicles

Criteria for the ideal ambulance vehicle are as follows:

(1) The ambulance should have a relatively standard design and should not be too expensive. Body styles should not be altered for esthetic or sales-promotion purposes, but rather when there is a need for adaptation to improved equipment or for increased efficiency. The ambulance should be one that can be repaired with standard equipment. Mechanical and body work should be available within a short distance from the base of operations.

(2) The exterior color should be standard on all ambulances. The top of the vehicle should be equipped with a rotating beacon of a standard color.

(3) The ambulance should not be equipped with a high-powered, high-speed motor.

(4) Suspension should ensure comfortable riding qualities.

(5) The wheelbase and road clearance should be appropriate to the community in which it is used.

(6) The interior should be well insulated, paneled, and upholstered in such a way that it can be readily cleaned and disinfected. All materials used should be resistant to fire, water, and chemicals.

(7) The patient compartment should be devoid of projecting objects. Movable equipment should be stored in waterproof and corrosionproof drawers that are easily removed for use outside the ambulance.

(8) The patient area should be well illuminated with artificial light that can be controlled by the attendant.

(9) The electrical system should be adequate for radio equipment, and there should be electrical outlets for suction and other equipment.

(10) All windows in the patient area should be sufficiently strong and shatterproof to prevent injury to a mentally disturbed patient.

(11) There should be provisions for central suction and built-in central oxygen storage.

(12) The ambulance should not be designed to accommodate more than two litter patients.

(13) A partition must separate the driver from the patient compartment, to protect the driver from mentally disturbed patients and to shield the driver from light in the patient compartment when driving at night.

(14) There must be adequate headroom for the attendant to administer patient care en route.

Equipment

The equipment should be the same, regardless of the type of ambulance service. To save lives and to keep transportation safe and sane, a properly trained ambulance attendant must have the equipment necessary to: (1) care for easily correctible airway obstructions, (2) institute proper cardiopulmonary resuscitation, (3) control accessible hemorrhage, (4) dress wounds, (5) immobilize fractures, and (6) transport the patient with maximum safety.

Communication

It is fundamentally important that each community have a central dispatch area. In a small town, this may be the office of an ambulance company. In a large urban community, it may be a central office that receives all incoming calls and dispatches ambulances from stations in various zones of the city.

Records should be maintained of incoming calls and of the times of dispatch and return of each vehicle. A dispatch center must be informed at all times of the location and availability of every ambulance and should control the movement of all vehicles.

A national ambulance telephone number is needed, e.g., "dial A M B for ambulance".

Usually the first person at the scene of an emergency or disaster is a police officer. Easy

and efficient communication between him, traffic control authorities, ambulance dispatchers, and hospitals is mandatory. If the emergency is one of magnitude, telephone lines are apt to be jammed; thus, radio communication is the most reliable. All concerned must be provided with tie-in units that will facilitate intercommunication. The means to be used in each community in establishing a communication system should be coordinated with regional, state and national systems.

Conclusions

Development of proper emergency ambulance services in the United States calls for:

(1) standards of organization and a continuing flow of information between local, regional, and state groups involved;

(2) standards of training in immediate care, provisions for appropriate consultation, and manuals and teaching aids;

(3) specifications for ambulance vehicles;

(4) standardization of equipment and supplies and establishment of the Letterman system of exchange; and

(5) coordinated system of emergency communication.

Addendum III

Food Additives

The following additives may be used in connection with the production, packaging, and storage of food products, under certain specified conditions, for a period of 1 year from March 6, 1960, or until regulations have been issued:

(a) *General list.*

Product	Limits	Specified uses or restrictions
Bromides, inorganic	50 parts per million	In processed foods from methyl bromide fumigation of food plant use.
Carbon tetrachloride	300 parts per million	As a fumigant in food plant use.
Coumarone-indene resin		In coating on citrus fruits.
Chloropicrin		As a fumigant in food plant use.
Dibutyl phthalate		Not to exceed 2.17 percent in nitrocellulose-coated, heat-sealing cellophane for packaging foods.
Dicyclohexyl phthalate		As a fumigant in food plant use.
Ethylene dibromide		Do.
Ethylene dichloride		Not to exceed 0.40 percent in nitrocellulose-coated, heat-sealing, cellophane for packaging foods.
Maleic acid		Not to exceed 2 percent in fiber bags to contain dry foods.
Mineral oil		Not to exceed 0.8 percent in film wrapping for food.
Mono fatty acid ester of polyethylene glycol		Not to exceed 0.09 percent in nitrocellulose-coated, heat-sealing, cellophane for packaging foods.
Pentaerythritol tetrastearate		As a fumigant in food plant use.
Piperonyl butoxide		Not to exceed 0.04 percent in nitrocellulose-coated, heat-sealing cellophane for packaging foods.
Polymers of pinaric and abietic acids and/or rosin constituents		Not to exceed 1.48 percent in film wraps for meat, as an emulsifier.
Polyoxyethylene (20) sorbitan monooleate		As a fumigant in foods.
Propylene oxide		Do.
Pyrethrins		Not to exceed 1.77 percent in coatings for food-storage containers.
Tetrachlorethylene pentamine		Not to exceed 20 percent in adhesives for food packages.
Titanium dioxide	150 parts per million in food	As a pigment when used as a component of packaging materials excluding confectionery.
Mineral oil (including petrolatum)	10 parts per million in food	As a fumigant in processed, cupped or extruded food, excluding confectionery.
Do	do	As a secondary plasticizing agent in rubber belting, hose, or rollers having food contact, but not to include confectionery.
Do	50 parts per million in meat	As a release agent in drying pans in preparing dried fruits and vegetables.
Do	200 parts per million in dried fruits and vegetables.	In baking industry as dough-divider oil, pan oil, and trough grease.
Do	1,500 parts per million in bakery products.	As a release agent in drying pans in preparing dried egg albumin.
Do	1,000 parts per million in dried egg albumin.	As a migrant when used as a component of food-packaging materials.
Polyethylene		As a constituent of food-packaging materials and protective coatings; as a lubricant or release agent.
Wax, microcrystalline, and paraffin		
Type I: A congealing point of 160° F. maximum (ASTM D-938), an absorptivity at 280 millimicrons of 0.04 liter per gram centimeter maximum (ASTM E-131), an oil content of 1.6% maximum (ASTM D-721), and a Saybolt color of 20 minimum (ASTM D-156).		
Type II: Absorptivity at 280 millimicrons of 1.0 maximum, an oil content of 5.0% maximum, and a color of 3.0 maximum (ASTM D-1500).		
Castor oil phthalate		Not to exceed 0.26 percent in cellophane film for food packaging.
Chromium oxide green		As a colorant in food containers.
Dicyclohexyl phthalate		Not to exceed 2.84 percent in cellophane film for food packaging.
Isobutene and isoprene or butylene		Not to exceed 8.0 percent in wax coating for food packaging.
Oleic acid, potassium soap		As defoaming agent in paper and paperboard used for food packaging.
Oleic acid, sodium soap		Do.
Paraffin, synthetic (Fischer-Tropsch)		Not to exceed 15 percent in coatings for food wraps.
Phthalimidoethyl propionate		Not to exceed 0.71 percent in cellophane film for food packaging.
Polyamide resin (dimerized vegetable fats and diethylenetriamine)		As component of food wraps.
Polybutene		Not to exceed 8.0 percent in wax coating for food packaging.
Polyglycol 200		Not to exceed 0.04 percent in cellophane film for food packaging.
Polyglycol ether of octylphenol containing 10 mols of ethylene oxide		As defoaming agent in paper and paperboard used in food packaging.
Polyglycol ether of octylphenol containing 9 mols of ethylene oxide		Do.
Polyoxyethylene (20) sorbitan monostearate		Not to exceed 0.06 percent in cellophane film for food packaging.
Sorbitan monostearate		Do.
Tetrahydrofurfuryl		As solvent in preparation of cellophane for food packaging.
Triphenyl phosphite, alkylated		As a food packaging component.
Ultramarine blue		As a pigment in food containers and liners thereof.
Damar resin (natural East Indian resin)		As a component of films for food packaging.
Dibutyl phthalate		Do.
Dimerized rosin (made from rosin (wood, gum, or tall oil rosin or blends of these), using sulfuric acid as a catalyst)		Do.
Dimethylcyclohexyl phthalate		Do.
Hydrogenated castor oil phthalate		Do.
Itaconic acid, polymerized		Do.
Maleic anhydride rosin ester		Do.
Nylon resin (polyhexamethylenesebacamide)		In food-handling equipment other than for milk.
Nylon resin (copolymer of hexamethylenediamine and hexamethylenesebacamide)		Do.
Palmityl stearate		As a lubricant in polystyrene for food packaging.
Polysorbate 80 (polyoxyethylene (20) sorbitan monooleate)		Not to exceed 1.48 percent in film wraps for fruits and vegetables.
Sodium dodecylbenzene sulfonate		As a component of films for food packaging.
Sodium lauryl sulfate		As a component of food-packaging material.
Sperm oil, hydrogenated		As a lubricant in polystyrene for food packaging.
Toluene-sulfonamide formaldehyde resin		As a component of films for food packaging.
Triethylene glycol		Do.

(b) *Substances migrating from paper and paperboard products used in food packaging*—(1) *Defoaming agents.*

Aliphatic hydrocarbon fractions of petroleum.
Castor oil.
Cetyl alcohol.
Coconut alkylolamide.
Coconut oil, sulfonated.
Cottonseed fatty acid.
Cyclohexanol.
Diethanolamine stearate.
Ethylenediamine tetraacetic acid tetrasodium salt.
Formaldehyde.
Glyceryl monohydroxystearate.
Hexadecanol.
Hexylene glycol.
Hydrogenated fish oil.
Isobutanol.
Isopropanol.
Kerosene, completely aliphatic.
Kerosene oil.
Kerosene oil, deodorized.
Lauryl alcohol.
Lignin sulfonate sodium salt.
Marine oil fatty acid soaps (hydrogenated).
Methyl oleate.
Methyl oleate-palmitate mixture.
Methyl tallowate.
Mineral oil.
Mustardseed oil, sulfated.
Myristyl alcohol.
Naphtha.
Oleic acid, animal source.
Oleic acid, sulfated.
Oleic acid, vegetable source.
Oil paraffin.
Oil paraffin, pale paraffin oil.
Parachlorometacresol.
Paraffin wax.
Peanut oil, sulfated.
Pentaerythritol monostearate.
Polyalkylene glycol ether.
Polyethylene (slightly oxidized).
Polyethylene glycol, ester of rosin (15 M).
Polyethylene glycol, ester of rosin octylphenol.
Polyethylene glycol 200, monotallate.
Polyethylene glycol 200, monooleate.
Polyethylene glycol 200, monostearate.
Polyethylene glycol 400, ditallate.
Polyethylene glycol 400, dioleate.
Polyethylene glycol 400, distearate.
Polyethylene glycol 400, monococoate.
Polyethylene glycol 400, monolaurate.
Polyethylene glycol 400, monooleate.
Polyethylene glycol 400, monostearate.
Polyethylene glycol 400, monotallate.
Polyethylene glycol 400, tallow diester and glycerides.
Polyethylene glycol 450, monostearate.
Polyethylene glycol 600.
Polyethylene glycol 600 monooleate.
Polyethylene glycol 600, monoricinoleate.
Polyglycol ether of tridecyl alcohol.
Polyoxyethylene sorbitan monostearate.
Rice bran oil.
Rice bran oil, sulfated.
Ricinoleate (butyl).
Ricinoleate (methyl).
Sodium stearate, technical grade.
Sorbitan monostearate.
Sorbitan tristearate.
Sperm oil, sulfated (75%).
Stearic acid.
Stearic acid, single pressed.
Stearic acid, double pressed.
Stearic acid, rubber grade.
Stearic palmitic acids, 63:29.
Stearyl alcohol, technical grade, approximately 65%–80% stearyl and 20%–35% cetyl.
Tall oil fatty acid, methyl ester.
Tall oil, refined.
Tallow, alcohol, hydrogenated.
Tallow, blown (oxidized).
Tallow.
Tallow fatty acids.
Tallow fatty acids, hydrogenated.
Tallow, hydrogenated.
Tallow, monoglyceride.
Tallow, propylene glycol ester.
Tallow, sodium soap.
Tallow, sulfated (75%).
Tallow, sulfated (80%).
Tallow, sulfonated (50%).
Tallow, unbleached.
Triethanolamine (98%).
Triisopropanolamine.
Zinc stearate.

(2) *Rosin and rosin derivatives.* As incidental additives to food from the use as components of adhesives, wax and other coatings, plasticizers, inks, lacquers, sizings, paper finishers, defoaming and dispersing agents, intended for use in the manufacture of paper and paperboard for the packaging of food.

Wood rosin, gum rosin, and tall oil rosin and the dimers thereof, and these substances as modified by the following reactants:
Bisphenol-formaldehyde.
Ethylene glycol.
Formaldehyde.
Fumaric acid.
Glycerin.
Hydrogen.
Maleic anhydride.
Methanol.
Pentaerythritol (double-crystallized).
Phthalic anhydride.
Sulfuric acid.
Triethylene glycol.

(3) *Miscellaneous chemicals and substances used in the manufacture of paper and paperboard for food packaging.* As incidental additives to food from the use as components of adhesives, wax, and other coatings, plasticizers, inks, lacquers, sizings, paper finishes, slime-control agents, dispersing agents, and/or other uses:

Acrylic and methacrylic esters (aqueous emulsions of polymers).
Animal glue.
Anionic polyacrylamide.
bis(1,4-Bromoacetoxy)-2-butene.
Carbon black prepared by the "impingement" or "channel" process.
Dibutyl phthalate.
Dicyclohexylphthalate.
Dicyandiamide.
Dimethyl polysiloxane polymer.
Dioctyl sodium sulfosuccinate.
Hydroxyethylcellulose.
β-Hydroxyethyl pyridinium salt of 2-mercaptobenzothiazole.
Hydroxyethyl starch.
Mixture of the ketene dimers of palmitic and stearic acids.
Monosulfonated naphthalene.
Oxidized starch.
Pentaerythritol ester of maleic anhydride.
Polyamide-epichlorohydrin resin.
Polyoxyethylated castor oil.
Polyoxyethylated oleyl alcohol.
Polyvinyl alcohol.
Sodium dodecylbenzene sulfonate.
Sodium lauryl sulfate.
Sodium ligninsulfonate (sodium lignosulfonate).
Sodium nitrate.
Sodium salt of naphthalene sulfonic acid condensed with formaldehyde.
Sodium salts of dimethyl dithiocarbamic acid and 2-mercaptobenzothiazole.
Triethylene glycol polyester of phthalic anhydride (modified).
Vinyl acetate dibutyl maleate copolymer.
Zinc dimethyldithiocarbamate in combination with zinc salt of 2-mercaptobenzothiazole.

(c) *Substances migrating from adhesives used in food packaging.* In addition to the requirements set forth in the introduction to this section, the following additives may be used in adhesives in packaging materials under the condition that a minimum quantity of the additive from the adhesive will be incorporated in the food, consistent with good manufacturing practice. While preliminary data show that many of the substances included in the list may not migrate to foods, these are being included pending the completion of additional scientific work involving them.

Acetone.
Albumin, blood.
Ammonium chloride.
Ammonium persulfate.
Ammonium silicofluoride.
Ammonium thiocyanate.
Benzol.
Benzyl alcohol.
Borated dextrin.
Borax.
Boric acid.
Butadiene acrylonitrile latex.
Butadiene-styrene latex.
Butyl acetate.
Butyl acetyl ricinoleate.
Butyl benzyl phthalate.
Butyl carbitol acetate.
Butyl cellosolve.
Candelilla wax.
Carbitol.
Carbitol acetate.
Carbon tetrachloride.
Carnauba wax.
Castor wax.
Cellosolve.
Cellosolve acetate.
Cellosolve ricinoleate.
Cellulose acetate butyrate.
Ceresin wax.
China clay.
Chlorinated biphenyl.
Copper 8-quinolinolate.
Diacetone alcohol.
Dibutyl phthalate.
Dicyandiamide.
Dicyclohexyl phthalate.
Diethylene glycol adipic acid polymer.
Diethylene glycol dibenzoate.
Diethylene glycol ester of resin.
Diethyl oxalate.
Diglycol laurate.
Dihydroxy abietyl phthalate.
Dihydroxydichlorodiphenyl methane.
Dimethyl phthalate.
Dimethyl polysiloxane.
Dioctyl phthalate.
Dioxane.
Diphenyl phthalate.
Dipropylene glycol dibenzoate.
Epsom salt.
Ethyl acetate.
Ethyl alcohol.
Ethyl cellulose.
Ethylene glycol.
di(2-Ethylhexyl) hexahydro phthalate.
Ethyl lactate.
Ethyl *p*-toluene sulfonamide.
Formaldehyde.
Formic acid.
Gelatin.
Glue (animal).
Glycerin ester of hydrogenated rosin.
Glycol fatty ester polymer.
Glyoxal.
Heptane.
Hexane.
Hexylene glycol.
Hydroabietyl alcohol.
Hydrofluosilicic acid.
Hydroxyacetic acid.
Hydroxyethyl cellulose.
Isopropyl acetate.
Isopropyl alcohol.
Tetra-Isopropyl titanate.
Latex (natural).
Lauryl alcohol sulfate.
Lauryl and myrstyl alcohols (sodium salts of sulfate monoesters).
Magnesium chloride.
Methanol.
Methyl acetate.
Methyl acetyl ricinoleate.
Methyl carbitol.
Methyl cellosolve.
Methylcellulose.
2,2-Methylene-bis-4-ethyl-6-*tert.*-butyl phenol.
2,2-Methylene-bis-4-methyl-6-*tert.*-butyl phenol.
Methylene chloride.
Methyl ester of hydrogenated rosin.
Methyl ethyl ketone.
Methyl phthalyl ethyl glycolate.
Mineral oil.
Montan Wax.
Morpholine.
Naphtha.
Neoprene latex.
Nitrocellulose.
Oleic acid.
Oleic acid and polyethylene glycol.
Oxazoline.
Ozocerite wax.
Parachloroethylene.
Phenol.
α-Pinene resin.
Polyalkylated phenol monosulfide.
Polyalkylene glycol ether.
Polyamide.
Polybutene.
Polyethylene.
Polyisobutylene.
Polylactyl.
Polyoxyethylene oleate.
Polyoxyethylene (4-phenol).
Polyoxyethylene sorbitan monolaurate.
Polyoxyethylene sorbitan monopalmitate.
Polyoxyethylene sorbitan monostearate.
Polyoxyethylene (40) stearate.
Polystyrene.
Polyvinyl acetate resin.
Polyvinyl alcohol.
Polyvinyl butyral.
Polyvinyl methyl ether.
Propylene carbonate.
Propylene glycol monococate.
α-Protein soybean.
Rosin (decarboxylated).
Rosin derivative (dymerex).
Rosin, gasoline-insoluble fraction.
Rosin glycerol ester, polymerized.
Rosin, hydrogenated wood, glycerin ester.
Rosin gum emulsion.
Rosin methylester.
Rosin modified with ammonium caseinate.
Rosin, pentaerythritol esters.
Rubber, butyl.
Shellac.
Silica (also colloidal).
Sodium alkyl amyl sulfonate.
Sodium carboxymethylcellulose.
Sodium decylsulfate.
Sodium dioctyl sulfosuccinate.
Sodium dodecylbenzene sulfonate.
Sodium 2-ethylhexyl sulfate.
Sodium formate.

Sodium metaborate.
Sodium nitrate.
Sodium nitrite.
Sodium o-phenylphenate.
Sodium perborate.
Sodium polyacrylate.
Sodium salts of dimethyl dithiocarbamic acid and 2-mercaptobenzothiazole.
Sodium silicate.
Sodium tetradecylsulfate.
Sorbitan monooleate.
Sorbitan monopalmitate.
Sorbitan monostearate.
Stearato chromic chloride.
Sulfonated castor oil.
Talc.
Tall oil soaps.
Terphenyl.
o- and p-Toluene ethyl sulfonamic ..
Toluol.
Tributyl citrate.
Tributyl phosphate.
Trichloroethylene.
Triethanolamine.
Urea.
Urea formaldehyde resins.
Xylol.
Zinc oxide.
Zinc sulfate.

(d) *Substances migrating from linings of containers used in food packaging.* In addition to the requirements set forth in the introduction to this section, the following additives may be used in linings of containers used in food packaging under the condition that a minimum quantity of the additive from the linings will be incorporated in the food, consistent with good manufacturing practice. While preliminary data show that many of the substances included in the list may not migrate to foods, these are being included pending the completion of additional scientific work involving them.

(1) Drying oils, including the triglycerides or fatty acids derived therefrom:

Chinawood.
Castor (including dehydrated).
Tall.
Linseed.
Oiticica.
Beechnut.
Candlenut.
Coconut.
Corn.
Cottonseed.
Fish (refined).
Hempseed.
Perilla.
Poppyseed.
Pumpkinseed.
Safflower.
Sesame.
Soybean.
Sunflower.
Walnut.

The oils may be raw, heat-bodied, or blown. They may be refined by filtration, degumming, acid or alkali washing, bleaching, distillation, partial dehydration, partial polymerization, or solvent extraction or modified by combination with maleic anhydride.

(2) Reconstituted oils from triglycerides or fatty acids derived from the oils listed in subparagraph (1) of this paragraph to form esters of:

Ethylene glycol.
Pentaerythritol.
Polyethylene glycol.
Polypropylene glycol.
Propylene glycol.
Sorbitol.
Trimethylol ethane.
Trimethylol propane.

(3) Synthetic drying oils:

Butadiene styrene copolymer.
Polybutadiene.

(4) Natural fossil resins:

Copal.
Damar.
Elemi.
Gilsonite.
Glycerol ester of damar, copal, elemi, and sandarac.
Minyak.
Sandarac.
Shellac.
Utah coal resin.

(5) Rosin derivatives, including modification by polymerization, isomerization, decarboxylation, and hydrogenation, and methyl ester of hydrogenated rosin:

Rosin esters:
Bisphenol-epichlorohydrin (epoxy).
Diethylene glycol.
Ethylene glycol.
Glycerol.
Methanol.
Pentaerythritol.
Rosin esters modified by reaction with:
Maleic anhydride.
Ortho-, meta-, and para-substituted phenol-formaldehyde as listed in subparagraph (6) of this paragraph.
Phenol-formaldehyde.
Calcium resinate (limed rosin).
Zinc rosinate.

(6) Phenolic resins by reaction of formaldehyde with:

Alkylated phenols (methyl, ethyl, propyl, isopropyl, butyl).
Bisphenol.
Ortho-, meta-, and paracresol.
Paracyclohexyl phenol.
Paranonyl phenol.
Paraoctyl phenol.
Paraphenyl phenol.
Paratertiary amylphenol.
Paratertiary butylphenol.
Phenol.
Xylenol.

(7) Polyester resins (including alkyd type) formed as ester of acids in subdivisions (i) and (ii) of this subparagraph, by reaction with polyhydric alcohols in subdivision (iii) of this subparagraph:

(i) Polybasic acids:

Adipic.
Dimerized fatty acids derived from oils listed in subparagraph (1) of this paragraph.
Fumaric.
Isophthalic.
Maleic.
Orthophthalic.
Rosin-maleic acid adduct (petrex acid).
Sebacic.
Terephthalic.
Trimellitic.

(ii) Monobasic acids:

Benzoic.
Fatty acids derived from oils listed in subparagraph (1) of this paragraph.
Rosins and rosin acids (see subparagraph (5) of this paragraph).
Tertiary butyl benzoic.

(iii) Polyhydric alcohol:

Glycerol.
Mannitol.
α-Methyl glucoside.
Pentaerythritol.
Propylene glycol.
Sorbitol.
Trimethylol ethane.
Trimethylol propane.

(8) Epoxy resins:

Bisphenol-epichlorohydrin.
Bisphenol-epicholorhydrin reacted with drying oils or fatty acids listed in subparagraph (1) of this paragraph.
Bisphenol-epichlorohydrin combined with:
Bisphenol-formaldehyde.
Diethylene triamine.
Melamine-formaldehyde.
Phenol-formaldehyde.
Urea formaldehyde.

(9) Coumarone-indene resin.
(10) Petroleum hydrocarbon resin.
(11) Terpene.
(12) Urea-formaldehyde.
(13) Triazine-formaldehyde resins:

Benzoguanamine.
Melamine.

(14) Modifiers (for oils and alkyds, including polyesters):

Butyl methacrylate.
Cyclopentadiene.
Diallyl phthalate.
Methyl methacrylate.
Styrene.
Vinyl toluene.

(15) Vinyl resinous substances:

Polyvinyl acetate.
Polyvinyl alcohol (for fatty foods only).
Polyvinyl butyral.
Polyvinyl chloride.
Polyvinyl formal.
Polyvinylidene chloride.
Polyvinyl pyrrolidone.
Polyvinyl stearate.
Vinyl chloride-acetate-copolymer.
Vinyl chloride-acetate, hydroxyl modified-copolymer.
Vinyl chloride-acetate, maleic acid modified-copolymer.
Vinyl chloride-acrylonitrile-copolymer.
Vinyl chloride-maleic ester-copolymer.
Vinyl chloride-vinylidene chloride-copolymer.

(16) Cellulosics:

Carboxymethylcellulose.
Cellulose acetate.
Cellulose acetate-butyrate.
Cellulose acetate-propionate.
Ethylcellulose.
Ethyl hydroxy ethylcellulose.
Hydroxy propyl methylcellulose.
Methylcellulose.
Nitrocellulose.

(17) Styrene polymers:

Polystyrene.
Polymethyl styrene.
Styrene-acrylonitrile copolymer.

(18) Polyethylene (branched and linear).
(19) Polypropylene.
(20) Acrylics and their copolymers:

Polybutyl methacrylate.
Polyethyl acrylate.
Polyethyl methacrylate.
Polymethyl acrylate.
Polymethyl methacrylate.

(21) Elastomers:

Butadiene-acrylonitrile copolymer.
Butadiene-acrylonitrile-styrene copolymer.
Butadiene-styrene copolymer.
Butyl rubber.
2-Chloro-1,3-butadiene (neoprene) (with acceptable stabilizer and/or antioxidant).
Polyisobutylene (for nonfatty foods only).
Rubber hydrochloride.
Styrene-isobutylene copolymer.

(22) Driers made by reaction of a metal from subdivision (i) of this subparagraph with acid, to form the salt listed in subdivision (ii) of this subparagraph:
(i) Metals:

Calcium.
Cobalt.
Iron.
Magnesium.
Manganese.
Zinc.
Zirconium.

(ii) Salt:

Caprylate.
Linoleate.
Naphthenate.
Octoate (2-ethylhexoate).
Oleate.
Palmitate.
Resinate.
Ricinoleate.
Soyate.
Stearate.
Tallate.

(23) Waxes:

Microcrystalline, and paraffin:
Type I: A congealing point of 160° F. maximum (ASTM D–938), an absorptivity at 290 millimicrons of 0.04 liter per gram centimeter maximum (ASTM E–131), an oil content of 1.5 percent maximum (ASTM D–721), and a Saybolt color of 20 minimum (ASTM D–156).
Type II: Absorptivity at 290 millimicrons of 1.0 maximum, an oil content of 5.0 percent maximum, and a color of 3.0 maximum (ASTM D–1500).
Montan.
Polyethylene.
Sperm oil.
Spermaceti.

(24) Plasticizers:
(i) Chemical type:

Acetyl tributyl citrate.
Acetyl triethyl citrate.
Aluminum mono-, di-, and tristearate.
Butyl stearate.
Butyl phthalyl butyl glycolate.
p-tert. Butyl phenyl salicylate.
Dibutyl sebacate.
di-2-Ethyl hexyl phthalate.
Diethyl phthalate.
Dioctyl sebacate.
Ethyl phthalyl ethyl glycolate.
2-Ethylhexyl diphenyl phosphate.
Glycerol.
Glyceryl monooleate.

Glyceryl triacetate.
di-Isobutyl adipate.
di-Isooctyl phthalate.
mono-Isopropyl citrate.
Propylene glycol.
Sorbitol.
Triethyl citrate.
mono-, di-, and Tristearyl citrate.

(ii) Epoxy type:

Epoxidized soybean oil (iodine number less than 6; oxirane oxygen content 6% minimum).
3(2-Xenoxyl)-1,2-epoxypropane.

(25) Release agents:

Linoleic acid amide.
Oleic acid amide.
Palmitric acid amide.
Petrolatum.
Polyethylene glycol 400, 1,500, and 4,000.
Polyethylene wax.
Polytetrafluoroethylene.
Silicones(not less than 300 centistokes).
Stearic acid amide.
Waxes, microcrystalline and paraffin, complying with the specifications set out in subparagraph (23) of this paragraph.

(26) Pigments and colorants:

Aluminum.
Aluminum hydrate.
Aluminum and potassium silicate (mica).
Aluminum mono-, di-, tristearate.
Aluminum silicate (china clay).
Barium sulfate.
Bentonite.
Bentonite, organic-base modified.
Burnt umber.
Calcium carbonate.
Calcium silicate.
Calcium sulfate.
Carbon black ("channel" process).
Iron oxides.
Magnesium oxide.
Magnesium silicate (talc).
Raw sienna.
Silica.
Tartrazine lake (certified FD)C Yellow No. 5 only).
Titanium dioxide.
Titanium dioxide-barium sulfate (approximately 70%–30% ratio).
Titanium dioxide-calcium sulfate (approximately 70%–30% ratio).
Titanium dioxide-magnesium silicate (approximately 70%–30% ratio).
Zinc oxide.

(27) Miscellaneous materials:

Ammonium citrate.
Ammonium potassium phosphate.
Calcium acetate.
Calcium ethyl acetoacetate.
Calcium glycerophosphate.
Calcium, sodium, and potassium oleates.
Calcium, sodium, and potassium ricinoleates.
Calcium, sodium, and potassium stearates.
Disodium hydrogen phosphate.
Lecithin (edible grade).
Magnesium, sodium, and potassium citrates.
Magnesium glycerophosphate.
Magnesium stearate.
Mono-dibutyl amine pyrophosphate
Mono-, di-, and tricalcium phosphate.
Mono-, di-, and trimagnesium phosphate.
Phosphoric acid.
Sodium pyrophosphate.
Sodium tetrapyrophosphate.
Tin stearate.

(28) Surface lubricants:

Cottonseed oil and other edible oils.
Dibutyl sebacate.
Dioctyl sebacate.
Glyceryl monostearate.
Palm oil.
Paraffin wax complying with the specifications set out in subparagraph (23) of this paragraph.
Petrolatum.
Stearic acid.
White (mineral) oil.

(e) *Substances migrating from cotton and cotton fabrics used in dry food packaging.* In addition to the requirements set forth in the introduction to this section, the following additives may be used in cotton fabrics used in dry food packaging under the condition that a minimum quantity of the additive from the fabrics will be incorporated in the food, consistent with good manufacturing practice. While preliminary data show that many of the substances included in the list may not migrate to foods, these are being included pending the completion of additional scientific work involving them.

Abietic acid.
Amyl acetate.
Borax.
Boric acid.
Butyl oleate.
Candelilla wax.
Cresylic acid.
Diethylene glycol esters of stearic acid, lauric acid, tallow, coconut oil.
Diethylene glycol ethyl ether.
Diethylene glycol monolaurate.
Ethyl esters of copolymers of polyacrylic acid and polymethylacrylic acid.
Ethylenediamine tetraacetate.
Ethylenediamine tetraacetic acid, sodium salt.
Ethylene glycol *N*-butyl ether.
Ethylene glycol ethyl ether.
2-Ethylhexanol.
Ethylene glycol *N*-hexyl ether.
Formaldehyde.
Glycerol esters of stearic acid, lauric acid, tallow, coconut oil.
Hexane-1,2-diol.
Isopropanol.
Methyl esters of copolymers of polyacrylic acid and polymethylacrylic acid.
Petroleum sulfonate (mahogany soap containing 50 percent mineral oil and 50 percent sulfonated petroleum oil).
Ortho-phenylphenol.
Pine oil.
Polyethylene.
Polyethoxylated alkyl phenols (polyoxyethylated alkyl phenols, prepared by ethylene oxide reaction on nonyl phenol containing up to 40 oxyethylene groups).
Polyethoxylated fatty acids (polyoxyethylated fatty acids, prepared by reacting ethylene oxide or polymers of ethylene oxides with oleic or coconut oil fatty acids, or tallow or coconut oil).
Polyethoxylated fatty alcohols (polyoxyethylated fatty alcohols, obtained by reaction of ethylene oxide with stearyl alcohol, oleyl alcohol, or cetyl alcohol).

Polyvinyl alcohol.
Propylene glycol esters of stearic acid, lauric acid, tallow, coconut oil.
Propyl oleate.
Soaps of tallow, stearic acid, oleic acid, tall oil fatty acids, and rosin.
Sodium dodecylbenzenesulfonate.
Sodium pentachlorophenate.
Stoddard solvent.
Sulfated castor oil, 75 percent.
Sulfated cetyl alcohol.
Sulfated corn oil.
Sulfated tallow.
Sulfated vegetable oil.
Sulfonated propyl, butyl, or isobutyl oleates, or mixtures of these.
Triethanolamine salt of dodecylbenzenesulfonate.
Urea-formaldehyde resins (prepared by reaction of varying amounts of urea with formaldehyde).
Wax, microcrystalline, and paraffin:
Type I: A congealing point of 160° F. maximum (ASTM D–938), an absorptivity at 290 mμ of 0.04 liter per gram centimeter maximum (ASTM E–131), an oil content of 1.5% maximum (ASTM D–721), and a Saybolt color of 20 minimum (ASTM D–156).
Type II: Absorptivity at 290 mμ of 1.0 maximum, an oil content of 5.0% maximum, and a color of 3.0 maximum (ASTM D–1500).
White mineral oil.

The following sources of radiation may be used in connection with the inspection and packaging of foods and control of food processes, under certain specified conditions, for a period of 1 year from March 6, 1960, or until regulations shall have been issued.

Product	Limits	Specified uses or restrictions
Sealed sources of radiation from radioactive isotopes (strontium 90, cesium 137).		At energy levels not exceeding 2.2 million electron volts for inspection of foods, food packages, and control of food processes.
X-radiation		Energy level of 300-kilovolt peak for inspection of foods, food packages, and control of food processes.

Spices, seasonings, essential oils, oleoresins, and natural extractives that are generally recogized as safe for their intended use without special restrictions. The following list does not contain cinchona bark (red), cinchona bark (yellow), orris root, orris (concrete, liquid), quinine, wintergreen, and methyl solicylate since further study is needed to determine what restrictions, if any, these may require.

(1) Spices and Other Natural Seasonings and Flavorings (Leaves, Roots, Barks, Berries, etc.)

Common name	*Botanical name of plant source*
Allspice	Pimenta officinalis Lindl.
Anise	Pimpinella anisum L.
Anise, star	Illicium verum Hook. f.
Basil, sweet	Ocimum basilicum L.
Basil, bush	Ocimum minimum L.
Bay	Laurus nobilis L.
Calendula	Calendula officinalis L.
Capers	Capparis spinosa L.
Capsicum	Capsicum frutescens L. or Capsicum annuum L.
Caraway	Carum carvi L.
Caraway, black (black cumin)	Nigella sativa L.
Cardamom (cardamon)	Elettaria cardamomum Maton.
Cassia, Chinese	Cinnamomum cassia Blume.
Cassia, Padang or Batavia	Cinnamomum burmanni Blume.
Cassia, Saigon	Cinnamomum loureirii Nees.
Cayenne pepper	Capsicum frutescens L. or Capsicum annuum L.
Celery seed	Apium graveolens L.
Chives	Allium schoenoprasum L.
Cinnamon, Ceylon	Cinnamomum zeylanicum Nees.
Cinnamon, Chinese	Cinnamomum cassia Blume.
Cinnamon, Saigon	Cinnamomum loureirii Nees.
Clary (clary sage)	Salvia sclarea L.
Cloves	Eugenia caryophyllata Thunb.
Coriander	Coriandrum sativum L.
Cumin (cummin)	Cuminum cyminum L.
Cumin, black (black caraway)	Nigella sativa L.
Dill	Anethum graveolens L.
Fennel, common	Foeniculum vulgare Mill.
Fennel, sweet (finocchio, Florence fennel).	Foeniculum vulgare Mill. var. dulce (DC) Alef.
Fenugreek	Trigonella foenum-graecum L.
Garlic	Allium sativum L.
Ginger	Zingiber officinale Rosc.
Glycyrrhiza	Glycyrrhiza glabra L. and other spp. of Glycyrrhiza.
Grains of paradise	Amomum melegueta Rosc.
Horseradish	Armoracia lapathifolia Gilib.
Lavender	Lavandula officinalis Chaix.
Licorice	Glycyrrhiza glabra L. and other spp. of Glycyrrhiza.
Mace	Myristica fragrans Houtt.
Marigold, pot	Calendula officinalis L.
Marjoram, pot	Majorana onites (L.) Benth.
Marjoram, sweet	Majorana hortensis Moench.

SPICES AND OTHER NATURAL SEASONINGS AND FLAVORINGS (LEAVES, ROOTS, BARKS, BERRIES, ETC.)—Continued

Common name	*Botanical name of plant source*
Mustard, black or brown	Brassica nigra (L.) Koch.
Mustard, brown	Brassica juncea (L.) Coss.
Mustard, white or yellow	Brassica alba (L.) Boiss.
Nutmeg	Myristica fragrans Houtt.
Oregano (oreganum, Mexican oregano, Mexican sage, origan).	Lippia spp.
Paprika	Capsicum annuum L.
Parsley	Petroselinum crispum (Mill.) Mansf.
Pepper, black	Piper nigrum L.
Pepper, cayenne	Capsicum frutescens L. or Capsicum annuum L.
Pepper, red	Do.
Pepper, white	Piper nigrum L.
Peppermint	Mentha piperita L.
Poppy seed	Papaver somniferum L.
Pot marigold	Calendula officinalis L.
Pot marjoram	Majorana onites (L.) Benth.
Rosemary	Rosmarinus officinalis L.
Rue	Ruta graveolens L.
Saffron	Crocus sativus L.
Sage	Salvia officinalis L.
Savory, summer	Satureia hortensis L. (Satureja).
Savory, winter	Satureia montana L. (Satureja).
Sesame	Sesamum indicum L.
Spearmint	Mentha spicata L.
Star anise	Illicium verum Hook. f.
Tarragon	Artemisia dracunculus L.
Thyme	Thymus vulgaris L.
Turmeric	Curcuma longa L.
Vanilla	Vanilla planifolia Andr. or Vanilla tahitensis J. W. Moore
Zedoary	Curcuma zedoaria Rosc.

(2) ESSENTIAL OILS, OLEORESINS (SOLVENT-FREE), AND NATURAL EXTRACTIVES (INCLUDING DISTILLATES)

Common name	*Botanical name of plant source*
Allspice	Pimenta officinalis Lindl.
Almond, bitter (free from prussic acid)	Prunus amygdalus Batsch, Prunus armeniaca L., or Prunus persica (L.) Batsch.
Angelica root	Angelica archangelica L.
Angelica seed	Do.
Angelica stem	Do.
Angostura (cusparia bark)	Galipea officinalis Hancock.
Anise	Pimpinella anisum L.
Asafetida	Ferula assa-foetida L. and related spp. of Ferula.
Balsam of Peru	Myroxylon pereirae Klotzsch.
Basil	Ocimum basilicum L.
Bay leaves	Laurus nobilis L.
Bay (myrcia oil)	Pimenta racemosa (Mill.) J. W. Moore.
Bitter almond (free from prussic acid)	Prunus amygdalus Batsch, Prunus armeniaca L., or Prunus persica (L.) Batsch.
Bois de rose	Aniba rosaeodora Ducke.
Cananga	Cananga odorata Hook. f. and Thoms.
Capsicum	Capsicum frutescens L. and Capsicum annuum L.
Caraway	Carum carvi L.
Cardamon seed (cardamon)	Elettaria cardamomum Maton.
Carob bean	Ceratonia siliqua L.
Cascarilla bark	Croton eluteria Benn.
Cassia bark, Chinese	Cinnamomum cassia Blume.
Cassia bark, Padang or Batavia	Cinnamomum burmanni Blume.
Cassia bark, Saigon	Cinnamomum loureirii Nees.
Celery seed	Apium graveolens L.
Chamomile flowers, Hungarian (camomile)	Matricaria chamomilla L.
Chamomile flowers, Roman or English (camomile).	Anthemis nobilis L.
Cherry, wild, bark	Prunus serotina Ehrh.
Chicory	Chicorium intybus L.
Cinnamon bark, Ceylon	Cinnamomum zeylanicum Nees.
Cinnamon bark, Chinese	Cinnamomum cassia Blume.
Cinnamon bark, Saigon	Cinnamomum loureirii Nees.
Cinnamon leaf, Ceylon	Cinnamomum zeylanicum Nees.
Cinnamon leaf, Chinese	Cinnamomum cassia Blume.
Cinnamon leaf, Saigon	Cinnamomum loureirii Nees.
Citronella	Cymbopogon nardus Rendle.
Citrus peels	Citrus spp.
Clary (clary sage)	Salvia sclarea L.
Clove bud	Eugenia caryophyllata Thunb.
Clove leaf	Do.
Clove stem	Eugenia caryophyllata Thunb.

Common name	*Botanical name of plant source*
Coca (decocainized)	Erythroxylum coca Lam. and other spp. of Erythroxylum.
Coffee	Coffea spp.
Cola nut	Cola acuminata Schott and Endl., and other spp. of Cola.
Coriander	Coriandrum sativum L.
Cumin (cummin)	Cuminum cyminum L.
Cusparia bark	Galipea officinalis Hancock.
Dill	Anethum graveolens L.
Estragole (esdragol, esdragon, tarragon).	Artemisia dracunculus L.
Fennel, sweet	Foeniculum vulgare Mill.
Fenugreek	Trigonella foenum-graecum L.
Garlic	Allium sativum L.
Geranium, East Indian	Cymbopogon martini Stapf.
Geranium, rose	Pelargonium graveolens L'Her.
Ginger	Zingiber officinale Rosc.
Glycyrrhiza	Glycyrrhiza glabra L. and other spp. of Glycyrrhiza.
Grapefruit	Citrus paradisi.
Guava	Psidium spp.
Hoarhound	Marrubium vulgare L.
Hops	Humulus lupulus L.
Jasmine	Jasminum officinale L. and other spp. of Jasminum.
Juniper (berries)	Juniperus communis L.
Kola nut	Cola acuminata Schott and Endl., and other spp. of Cola.
Laurel leaves	Laurus mobilis L.
Lavender	Lavandula officinalis Chaix.
Lavender, spike	Lavandula latifolia Vill.
Lavandin	Hybrids between Lavandula officinalis Chaix and Lavandula latifolia Vill.
Lemon	Citrus Limon (L.) Burm. f.
Lemon grass	Cymbopogon citratus DC. and Cymbopogon flexuosus Stapf.
Licorice	Glycyrrhiza glabra L. and other spp. of Glycyrrhiza.
Lime	Citrus aurantifolia Swingle.
Locust bean	Ceratonia siliqua L.
Mace	Myristica fragrans Houtt.
Mandarin	Citrus reticulata Blanco.
Marjoram, sweet	Majorana hortensis Moench.
Maté	Ilex paraguariensis St. Hil.
Mustard	Brassica spp.
Naringin	Citrus paradisi Macf.
Neroli, bigarade	Citrus aurantium L.
Nutmeg	Myristica fragrans Houtt.
Onion	Allium cepa L.
Orange, bitter, flowers	Citrus aurantium L.
Orange leaf	Citrus sinensis (L.) Osbeck.
Orange, bitter, peel	Citrus aurantium L.
Orange, sweet	Citrus sinensis (L.) Osbeck.
Origanum	Origanum spp.
Palmarosa	Cymbopogon martini Stapf.
Paprika	Capsicum annuum L.
Parsley	Petroselinum crispum (Mill.) Mansf.
Pepper, black	Piper nigrum L.
Pepper, white	Piper nigrum L.
Peppermint	Mentha piperita L.
Peruvian balsam	Myroxylon pereirae Klotzsch.
Petitgrain	Citrus aurantium L.
Petitgrain lemon	Citrus limon (L.) Burm. f.
Petitgrain mandarin or tangerine	Citrus reticulata Blanco.
Pimenta	Pimenta officinalis Lindl.
Pimenta leaf	Do.
Pipsissewa leaves	Chimaphila umbellata Nutt.
Pomegranate	Punica granatum L.
Prickly ash bark	Xanthoxylum (or Zanthoxylum) Americanum Mill. or Xanthoxylum clava-herculis L.
Rose absolute	Rosa alba L., Rosa centifolia L., Rosa damascena Mill., Rosa gallica L., and vars. of these spp.
Rose (otto of roses, attar of roses)	Do.
Rose geranium	Pelargonium graveolens L'Her.
Rosemary	Rosmarinus officinalis L.
Rue	Ruta graveolens L.
Saffron	Crocus sativus L.
Sage	Salvia officinalis L.

ESSENTIAL OILS, OLEORESINS (SOLVENT-FREE), AND NATURAL EXTRACTIVES (INCLUDING DISTILLATES)—Continued

Common name	*Botanical name of plant source*
Sage, Spanish	Salvia lavandulaefolia Vahl.
St. John's bread	Ceratonia siliqua L.
Schinus molle	Schinus molle L.
Spanish sage	Salvia lavandulaefolia Vahl.
Spearmint	Mentha spicata L.
Spike lavender	Lavandula latifolia Vill.
Tangerine	Citrus reticulata Blanco.
Tarragon	Artemisia dracunculus L.
Tea	Thea sinensis L.
Thyme	Thymus vulgaris L. and Thymus zygis var. gracilis Boiss.
Thyme, white	Do.
Tuberose	Polianthes tuberosa L.
Turmeric	Curcuma longa L.
Vanilla	Vanilla planifolia Andr. or Vanilla tahitensis J. W. Moore.
Violet leaves absolute	Viola odorata L.
Wild cherry bark	Prunus serotina Ehrh.
Ylang-ylang	Cananga odorata Hook. f. and Thoms.
Zedoary bark	Curcuma zedoaria Rosc.

(3) MISCELLANEOUS

Common name	*Derivation*
Civet (zibeth, zibet, zibetum)	Civet cats, Viverra civetta Schreber and Viverra zibetha Schreber.
Cognac oil, white and green	Ethyl oenanthate, so-called.
Musk (Tonquin musk)	Musk deer, Moschus moschiferus L.

The following additives may be used in food, under certain specified conditions, for a period of one year from March 6, 1960, or until regulations shall have been issued establishing or denying tolerances or exemptions from the requirement of tolerances.

Product	Limits: percent or parts per million	Specified uses or restrictions
Activated charcoal complying with specifications of The National Formulary, Tenth Edition.	0.4	Pigment in food processing
Aluminum stearate		As a constitutent of chewing gum base.
Annatto colorants		As a colorant in foods in accordance with good manufacturing practice.
Butylated hydroxyanisole and/or butylated hydroxytoluene.	50 parts per million (combined total)	As an antioxidant in dehydrated potatoes and breakfast cereals.
Butylated hydroxyanisole and/or butylated hydroxytoluene.	0.001 percent (combined total)	As an antioxidant in dry mixes for making prepared foods.
Butyl rubber (chewing gum grade) without inhibitor		As a constituent of chewing gum base
Calcium disodium-ethylenediamine tetracetic acid dihydrate.	25 parts per million	As a sequestrant in malt beverages.
Calcium disodium-ethylenediamine tetracetic acid dihydrate.	75 parts per million	As a sequestrant in canned pineapple chunks (non-standardized article).
Calcium steraryl-2-lactylate.	0.5 percent	In egg white solids.
Calcium steraryl-2-lactylate	0.05 percent	In liquid and frozen egg whites.
Calcium steraryl-2-lactylate	0.35 percent	In nonstandarized bakery products.
Carbon black prepared by the "impingement" or "channel" process.	0.4	Pigment in food processing.
Carbon monoxide	Available data indicates no residue in foods ready to eat.	As an incidental constituent of inert or flue gas produced by the combustion of natural gas and used to displace or remove oxygen in the processing and packaging of nonstandarized foods.
Charcoal, nonactive, produced by retort method to conform with requirements of U. S. P. X.		In foods, according to good manufacturing processes.
Copper pyrophosphate	0.005 percent of copper in total daily ration	In mineral mixtures used in concentrated animal feeds.
Cottonseed flour (cooked and partially defatted.)	5 percent	In bakery products.
p-Coumarone		As a constituent of chewing gum base.
Coumarone-indene resin		As a constituent of chewing gum base.
3, 5-Diiodosalicylic acid	300 parts per million	In salt blocks for animal use.
Disodium dihydrogen-ethylene diamine tetraacetic acid	75 parts per million	As a sequestrant in canned pineapple chunks) nonstandarized article.)
Estergums (rosins or hydrogenated rosin reacted with glycerin or pentaerythritol and polymers.)		As a constituent of chewing gum base.
Ethyl cellulose	35 percent weight	In dry vitamin preparation for animal feed and human food use.
Ethylene dichloride	0.01 percent	Residue in production of spice oleoresins.
Ethylene oxide		In dried fruit as a residue from use as a fumigant, applied at rate of 0.4 milliliter per pound of dried fruit.
Ethylene oxide	50 parts per million	In ground spices as a residue from use as a fumigant.
Fat (animal and vegetable) hydrolyzed (free of toxic impurities).	12.5 percent	In feed for livestock and poultry.
Fumaric acid	0.3 percent	In foods as an acidulent flavoring and leavening agent.
Glyceryl abietate (ester gum)	100 parts per million	In citrus-flavored beverages.
Glycerol monooleate (from chick-tested material or if prepared from ester-exchange process)	3.5 parts per million	In fluid milk as vitamin oil emulsifier.
Gums (natural) of vegetable origin		As a constituent of chewing gum base.
Hydrogen cyanide	25 parts per million	As a residue from the use of Hydrogen cyanide as a fumigant.
Isobutylene-isopreme		As a constituent of chewing gum base.
Isobutylene resin		As a constituent of chewing gum base.
Lanolin		As a constituent of chewing gum base.
Latex (butadiene styrene rubber)		As a constituent of chewing gum base.
Lecithin, hydroxylated		Not to exceed 0.5 percent as an emulsifier in foods, excluding standardized foods.
Mannitol		If an amount of the food that may reasonably be consumed as an average serving contains 2.5 grams or more of mannitol in an average serving of the food which shall be expressed in terms of a convenient unit or units of such food or a convenient unit of measure that can be readily understood and utilized by purchasers of such food. The label shall also bear a statement that the consumption of more than 7.5 grams of mannitol at one time or more than 20 grams of mannitol per day may have laxative effects.
Metaldehyde	Zero residue on strawberries at time of harvest	One pound per acre as a spray, or dust on strawberries, applied not less than 14 days before harvest, for control of slugs and snails.
Methyl ester of rosin (hydrogenerated).		As a constituent of chewing gum.
Methylethylcellulose	3.0 percent	In vegetable fat whipped topping.
Methyl formate		In raisins and currants as a residue from use as a fumigant, applied at a rate of 0.77 milliliter per pound of fruit.
Mineral oil	3.3 parts per million	As a constituent of defoaming agent used in manufacture of beet sugar.
Mineral oil (including petrolatum)	600 parts per million in total ration	As a lubricant or dust-control agent in bulk animal feed and pelletized animal feed, including salt blocks for animal use.
Mono-and diglycerides prepared from oleic acid in accordance with extension granted in this order		As an emulsifier in foods.
Monoglyceride citrate	200 parts per million	As an antioxidant in fats.
Oleic acid prepared from edible fats and oils free from chick-edema factor		In foods and in the manufacture of food components.
Oxystearin	1,250 parts per million	In salad oils as inhibitor.
Petroleum hydrocarbon resin		As a constituent of chewing gum base.
Polyethylene		As a constituent of chewing gum base.
Polyethylene glycol 400 monooleate	10 percent of fat content	To emulsify the fat and as defoaming agent in calf-feed milk replacer.

Product	Limits percent or parts per million	Specified uses of restrictions
Polyoxyethylene (20) sorbitan monooleate or tristearate	0.1 percent	In frozen desserts (other) than water ices), as an emulsifier.
Polyoxyethylene (20) sorbitan monooleate	0.1 percent	In imitation ice cream, as an emulsifier.
Polyoxyethylene (20) sorbitan monooleate	0.05 percent	In pickles, as an emulsifier.
Polyoxyethylene (20) sorbitan monooleate or monostearate		As an emulsifier in flavored foods when used at rate not to exceed nine parts by weight per one part of flavor.
Polyoxyethylene (20) sorbitan monostearate	0.475 percent	In cakes, as an emulsifier.
Polyoxyethylene (20) sorbitan monostearate	0.45 percent	In cake icing, as an emulsifier.
Polyoxyethylene (20) sorbitan monostearate	0.5 percent	In confectionery coating, as an emulsifier.
Polyoxyethylene (20) sorbitan monostearate	0.2 percent	In sugar confectionery pan coatings as an emulsifier.
Polyoxyethylene (20) sorbitan monostearate	0.4 percent	In whipped topping, as an emulsifier.
Polysorbate 80		As a solubilizer in essential oils.
Polysorbate 80 (polyoxyethylene (20) sorbitan monooleate		As an emulsifier or solubilizer in vitamin preparations, providing for not more than 280 milligrams daily for children and not more than 500 milligrams daily for adults.
Polysorbate 80 (polyoxyethylene (20) sorbitan monooleate	0.26 parts per million	In fluid milk, from its use as a dispersing agent for Vitamin D concentrate.
Polyvinylpyrrolidone	170 parts per million	In vinegar as a residue from precipitating undesirable constituents (tannins).
Polyvinylpyrrolidone	400 parts per million	In wine as a residue from precipitating undesirable constituents (tannins).
Propylene glycol ether of methylcellulose		Thickener, stabilizer, protective colloid, suspending agent, emulsifier, and film former in foods.
Propylgallate	0.005 percent (combined total)	As antioxidants in breakfast cereals.
Quinine sulfate	0.01 percent	As flavoring agent in carbonated beverages.
Rubber (natural), smoked sheet, and latex solids.		As a constituent of chewing gum base.
Sodium dodecylbenzene sulfonate	2 parts per million	In fruits and vegetables as residue from its use as a detergent.
Sodium lauryl sulfate	125 parts per million	As a stabilizer in liquid and frozen egg whites.
Sodium lauryl sulfate	1,000 parts per million	As a stabilizer in egg white solids.
Sodium nitrate	10 parts per million	In cured tuna fish.
Sodium nitrate	20 parts per million	In canned pet animal food containing fish and/or meat.
Sorbitol		If an amount of the food that may reasonably be consumed as an average serving contains 5 grams or more of sorbitol, the label shall bear, a statement of the number of grams of sorbitol in an average serving of the food. The average serving shall be expressed in terms of a convenient unit or units of such food or a convenient unit of measure that can be utilized and readily understood by purchasers of such food. The label shall also bear a statement that the consumption of more than fifteen grams of sorbitol at one time or more than 40 grams of sorbitol per day may have laxative effects.
Sorbitol monostearate		As an emulsifier in flavored foods when used at rate not to exceed nine parts by weight per one part of flavor.
Sorbitan monostearate in combination with polyoxyethylene (20) sorbitan monostearate	0.475 percent	In cakes, as an emulsifier.
Sorbitan monostearate in combination with polyoxyethylene (20) sorbitan monostearate	1.0 percent	In confectionery coating, as an emulsifier.
Sorbitan monostearate in combination with polyoxyethylene (20) sorbitan monostearate	0.4 percent	In whipped topping, as an emulsifier.
Starch, oxidized, prepared by treating starch water suspension with sodium hypochlorite and hydrogen peroxide		As an ingreadient and stabilizer in prepared foods.
di-Starch phosphate (amylopectin reacted with sodium trimetaphosphate).	5 percent	As a modified starch in food.
Stearic acid, prepared from edible fats and oils, and free from chick-edema factor.		In foods and in the manufacture of food components.
Terpene resin		As a constituent of chewing gum base.
Titanium dioxide N F	0.4 percent	In baked goods and confectionery as pigment.
Trichloroethylene	10 parts per million	As a residual solvent in manufacture of decaffeinated coffee.
Ultramarine blue	0.50 percent	In salt for animal feeds.
Wax, microcrystalline, and paraffin Type I: A congealing point of 160° F. maximum (ASTM D-938), an absorptivity at 290 millicrons of 0.04 liter per gram centimeter maximum (ASTM E-131), an oil content of 1.5% maximum (ASTM D-721), and a Saybolt color of 20 minimum (ASTM D-156). Type II: Absorptivity at 290 millimicrons of 1.0 maximum, and oil content of 5.0% maximum, and a color of 3.0 maximum (ASTM D-1500).		As a coating on fruits, vegetables, and cheese. As a masticatory substance in chewing gum.

Absorption field, sewage, 554-556
Acanthocheilonema, 67
Accelator, 259
Accident, prevention, 40, 1142, 1207, 1248-1251, 1311-1313, 1471
Achromobacter, 215; lipolyticum, 604; perolens, 1017
Acids, food additives, 819
Acidity, 53-54; milk, 1116; water, 222, 409
Acidification, sludge, 516
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